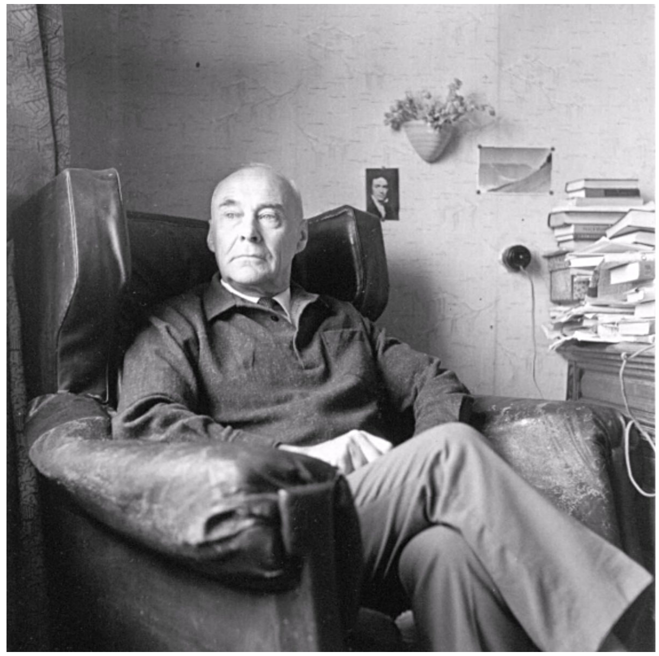
Foreword of the Editor

Today I am pleased to present to readers the English translation of *Causal or Asymmetric Mechanics*, written in 1958 by Prof. Nikolai A. Kozyrev, an eminent astronomer of the 20th century, widely recognized due to his astronomical discoveries such as lunar volcanism, the hydrogen atmosphere of Mercury, water vapour in the rings of Saturn, lightning in the atmosphere of Venus, and many others. We have already published his fundamental work on the sources of stellar energy and the internal constitution of stars (*Progress in Physics*, 2005, v. 1, no. 3), as well as his biography (*Progress in Physics*, 2009, v. 5, no. 3).

In addition, Kozyrev was an outstanding theoretical and experimental physicist. In the framework of his theory that he called "causal mechanics", he derived causal relations in the forces acting in classical mechanics, and then, in numerous physical experiments, he investigated the theoretically derived second-order effects caused by these causal relations. Causal mechanics is a truly outstanding scientific study, a modern fundamental extension of classical mechanics, which places Kozyrev in the row with the great physicists of the 19th and 20th centuries.

This publication includes two short essays written by the persons who closely collaborated with Prof. Kozyrev commencing in 1974. Prof. Mikhail L. Arushanov looked for the effects of causal mechanics in geophysical phenomena, in particular — in the Earth's atmosphere, among weather phenomena. He was so kind enough that translated *Causal or Asymmetric Mechanics* into English for our journal. Prof. Sergey M. Korotaev as well looked for the causal mechanical effects in geophysics, and also studied the origin of these effects in non-local quantum mechanics. Our Editorial Board is grateful to them for their cooperation, thanks to which Kozyrev's fundamental research will now be more accessible to a wider range of readers among the scientific community.

Dmitri Rabounski, Editor-in-Chief



Nikolai A. Kozyrev at his home cabinet, 1970s

Translator's Preface

Nikolai Aleksandrovich Kozyrev (1908–1983) was an outstanding scientist, astrophysicist, and thinker, whose life and scientific trajectory represent a unique example of the resilience of the human spirit. Endowed with a distinct talent, he made a fundamental contribution to theoretical astrophysics in his early years. However, his brilliant career was interrupted by the tragic events of the Stalinist repressions; he was arrested in 1936 on a false denunciation.

For Kozyrev, the decade of imprisonment became a period of profound internal concentration. Under conditions of complete isolation, physical exhaustion, and the absence of scientific literature, through the power of pure intellect alone, he arrived at his principal conclusions regarding the physical properties of time. Causal, or asymmetric, mechanics was created not in the quietude of academic offices, but as a result of the triumph of human thought over the cruelty of violence.

Even after his release and return to science, Kozyrev remained a pioneer ahead of his time. His discovery of tectonic activity and volcanism on the Moon caused a global sensation. In recognition of this breakthrough, he was awarded the Named Gold Medal of the International Academy of Astronautics in 1969. The significance of this rare international award can hardly be overstated: in the Soviet Union, only two people possessed it — the space pioneer Yuri Gagarin and the discoverer of lunar volcanoes Nikolai Kozyrev. The brilliant and acknowledged discovery of lunar volcanism was not achieved by accidental luck: he knew what to look for and where to find it!

This new type of interaction was viewed by N. A. Kozyrev as an entirely specific type of connection that is not mediated by momentum-transporting carriers: any irreversible thermal or chaotic process (for instance, combustion, dissolution, or thermodynamic processes within a star) acts as a source of macroscopic non-locality, generating measurable non-local correlations with the environment.

The interest of the author of this preface in causal mechanics was conceived in the mid-seventies of the last century owing to Sergey M. Korotaev. By a twist of fate, our acquaintance took place during military service in Tashkent. Initially, this fascination remained abstract, but it soon developed into concrete research: we decided to apply N. A. Kozyrev's concept to our shared professional field — geophysics.

We succeeded in promptly locating his two fundamental works: *Causal or Asymmetric Mechanics* and the collected volume *Time in Science and Philosophy*, which contained his article on this subject. Reading these works left an indelible impression and determined the direction of our subsequent inquiries. As an object of study, we considered various natural analogues of Kozyrev's gyroscope — up to and including an atmospheric cyclone. Ultimately, however, it was decided to build upon the ideas of Kozyrev himself, who viewed the Earth as a global gyroscope with an internal distribution of causal force pairs. On this basis, we focused on studying the planet's stress field under a zero integral over its entire volume — specifically, the distribution of the force first discovered by Kozyrev in a gyroscopic system, which is directed parallel to the gyroscope's axis and termed the causal force.

By considering the planet Earth as a global gyroscope, N. A. Kozyrev not only formulated the concept but also conducted a series of experiments to measure the vertical and horizontal components of the causal force within a certain latitudinal interval. In particular, he discovered a critical latitude ($73^\circ 05'$) at which the causal force changes its sign. However, the scientist did not leave an explicit theoretical expression for the distribution of this force across the Earth's surface.

Having set ourselves the task of filling this gap, we soon derived the the formula we were looking for. On its basis, the distributions of the field characteristics of mechanical stress were calculated, which revealed a striking regularity. The theoretical position of the critical latitude did not merely coincide with Kozyrev's experimental data. It turned out that virtually all previously known but seemingly disparate characteristics of the Earth's zonal asymmetry — the features of its geometric figure, geological structure, and global atmospheric circulation — find an exact and logical explanation through the action of this new, complementary causal force.

It is worth noting that during the derivation of the final expression, we slightly modified Kozyrev's original formula for the causal force, which indeed ensured such high agreement between the theory and empirical facts. After some hesitation, we sent a letter to Kozyrev outlining our results, without emphasizing the modification of his core formula. It was precisely this step that initiated our direct and long-term scientific communication.

Later in Moscow, where N. A. Kozyrev arrived for a conference, we met him in person. The personal acquaintance made a profound impression. Kozyrev, of course, immediately noticed that we had altered his formula in our own way. However, he did not refute our results; on the contrary, he promised to consider how to re-execute his earlier pendulum experiment (with a horizontal gyroscope axis) to verify our variant, but, unfortunately, he did not have time...

Both then and during subsequent repeated visits, we succeeded in witnessing almost all of his experiments firsthand. Although some of them were conducted in an explicitly non-rigorous manner, taken together, they were convincing. Even more convincing was the predictive power of the concept itself. For instance, one frequently heard counterargument from critics such as: "due to non-linear effects, vibrating balances can display anything". Yet, the crucial point is that they showed not "anything", but precisely what causal mechanics predicts. No non-linearity can explain either the change in the sign of the force when cause and effect are transposed, or the regular latitudinal dependency, and so forth.

The direct continuation of N. A. Kozyrev's research was impeded by two main factors: the weak formalization of the theoretical framework and the insufficient rigor of the early experiments. The scale and boldness of the conclusions of causal mechanics demanded flawless verification. What is permissible for a pioneer who moves swiftly forward, relying on intuition, is impermissible for his followers.

Later, the effects described by Kozyrev were successfully reproduced in many laboratories worldwide. However, the authors of these studies frequently omitted references to the primary source in their English-language publications. This circumstance — the desire to restore historical and scientific justice — served as one of the primary motivations for translating Kozyrev's fundamental work into English. Moreover, the methodological level of the experiments conducted by third-party researchers usually did not exceed the rigor of his original experiments, and at times fell short of them.

A rigorous physical experiment requires compliance with two mandatory conditions: the presence of a clearly and quantitatively formulated hypothesis, as well as an experimental design that allows for the deliberate isolation, suppression, or accounting of all possible sources of instrumental errors and environmental interference.

The first step in this direction was the formalization of the concept of causality based on the qualitative definition formulated by N. A. Kozyrev. A new method for experimental data analysis was developed — namely, causal analysis, initially in the framework of classical physics, and subsequently, by Dr. Sergey M. Korotaev, extended to quantum physics.

The path that began with Kozyrev's brilliant foresight has today acquired a rigorous mathematical and experimental framework. The present English edition is intended to restore the primary source to global scientific discourse and open new horizons in the study of the non-local nature of the Universe.

Prof. Mikhail L. Arushanov

Causal or Asymmetric Mechanics in a Linear Approximation

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Foreword

Recently, phenomena have been discovered in nuclear physics demonstrating the non-equivalence of the Universe and its mirror image. The author arrived at the existence of this asymmetry several years ago, based on astronomical data. Astronomical data indicate that the aforementioned asymmetry of the Universe exists due to the asymmetry of time, i.e., due to the objective difference between the future and the past. This property of time, which can be termed its directionality or course, establishes the distinction between causes and effects. Therefore, mechanics that takes into account the course of time is naturally called asymmetric or causal mechanics.

All natural phenomena unfold in time. Consequently, it is impossible to conceive of any branch of science studying the Universe in which the properties of time would not play a role. If the course of time indeed creates the non-equivalence of the Universe and its mirror image, then the phenomena of asymmetry in biology and in the microcosm must have the same explanation rooted in the directionality of time. It is difficult to speak of causal relationships existing within the microcosm. At the same time, it is only through simple experiments that allow for a visual, intuitive representation that the essence of time can be truly understood. Therefore, it seems to us that the physical study of the properties of time and causality should begin with experiments in elementary mechanics.

Chapter I. Astrophysical introduction

Currently, astrophysics seldom achieves unconditionally correct explanations for the observed phenomena of the stellar Universe. This pertains not only to specific, complex phenomena but also to fundamental phenomena of great generality that possess simple regularities. Refining physical conditions and utilizing a more sophisticated mathematical apparatus do not assist the theorist, nor do they provide the satisfying sense of a correctly resolved problem. From all this, one must conclude that we lack the knowledge required to solve astronomical problems. Evidently, there exists some profound principle in the Universe not yet discovered by modern natural science. This principle can hardly be invented; rather, it must be sought inductively, by theoretically solving inverse problems. In such an investigation, we must not bypass questions that are difficult for theory, but, on the contrary, focus our attention upon them.

Applying physical laws to explain the phenomena of the stellar Universe, we inevitably extend to the Cosmos all the consequences of the second law of thermodynamics as well. In the Universe, however, there are no signs of the degradation that follows from this second law. The Universe sparkles with inexhaustible diversity, and we find in it no traces of an approach toward thermal and radioactive death. Apparently, herein lies the fundamental contradiction — a very deep contradiction that cannot be eliminated by references to the infinity of the Universe. The fact is that not only individual astronomical objects but even entire systems are isolated from each other to such a degree that they can be considered closed systems. For them, thermal death should significantly approach before external assistance has time to arrive. Such degraded states of systems should be predominant, yet they are almost unnoticeable. Remaining within the framework of the ordinary laws of mechanics and physics, one is left to assume that the observed picture of the Universe is the result either of one vast catastrophe that once engulfed the entire Universe, or of minor, continuously occurring catastrophes that renew the Universe.

Such is the scope of ideas underpinning the cosmogonic and evolutionary constructs of astronomy, spanning from Newton to the present day, even though logically these catastrophes must be considered causeless, as they occur in defiance of the laws of nature.

It is interesting to note the similarity between these ideas and the views held by nineteenth-century geologists, prior to Lyell, regarding the history of life on the Earth. For instance, Cuvier and Leopold von Buch maintained that the development of the Earth occurred as a result of grandiose upheavals — so-called cataclysms — which periodically renewed the Earth. Today, geology relies upon the exceptionally fruitful principle of uniformitarianism, developed and substantiated by Lyell in 1830. As early as 1802, this principle was formulated by Lamarck: “The history of the Earth can be explained by proceeding solely from the ordinary forces of nature, which operate continuously in the present.” The scientific consistency and coherence of such a system of views are entirely evident. Seeking to remain equally consistent when explaining the development of the stellar Universe, we must recognize that there exist continuously operating Causes in nature that counteract the increase in entropy.

*Translated into English by Prof. Mikhail L. Arushanov and published in this Special Issue with the permission of Dmitry Kozyrev, one of the sons of Prof. Nikolai A. Kozyrev. Translated from: Kozyrev N. A. Causal or Asymmetric Mechanics in a Linear Approximation. Preprint, Pulkovo Astron. Observatory, 1958, 88 pages (*in Russian*).

The problem of overcoming the thermal death of the Universe is intimately linked to the problem of the origin of the luminosity of the Sun and the stars. The fact is that alterations to the second law are scarcely possible while preserving the first law of thermodynamics. Therefore, one may reason that by resolving the question of the nature of stellar energy, we shall find the key to understanding the most critical phenomena of the stellar Universe. Intense, irregular processes occur within stars, yet the general characteristics of stars — such as radius, mass, luminosity, the degree of rotational oblateness, and the like — must yield relationships that depend solely upon the primary causes. Consequently, one can anticipate that the theory of stellar structure will successfully resolve the following inverse problem: from the observed general characteristics, it is required to compute the physical conditions within the stars and to establish the physical circumstances under which the relationships found by observational astrophysics will be satisfied. In this problem, the number of unknowns is very large. Therefore, despite the sufficiency of the observed relationships, any attempt to solve it in a strictly mathematical manner is precluded.

In the first part of this study, which we initiated as early as 1937, a method was developed that enabled the rapid determination of observed characteristics — without excessive precision — under various assumptions regarding the conditions within stars [1]. As a result, it became possible to discern the specific conditions under which the most characteristic features of the observed relationships can be obtained within stars. The results of this analysis are presented in the second part of the work [2]. Here, we shall outline only the general course of reasoning and present the primary conclusions.

At present, the masses, radii, and luminosities (energy expenditure per unit time) for a significant number of stars are known from observations. Knowing the mass and radius, we can determine not only the density of a star but also its average gravitational energy. Consequently, for a gaseous sphere, the kinetic energy — and thus the internal temperature of the star — can be determined via the virial theorem. The luminosity of such a heated gaseous sphere will depend upon the temperature and the heat transfer conditions, which in turn are determined by temperature and density. Thus, both the luminosity of the star and the average energy loss per unit mass can be calculated as functions of mass and radius. Let us conceive a coordinate system in which the axes represent density, temperature, and energy expenditure per unit mass. We have seen that each of these variables depends upon two parameters: mass and radius. Therefore, within the specified space, stars must lie upon a certain surface. As it loses energy, a star will cool and contract, remaining upon this surface. The lifespan of such a star, as calculated by Helmholtz and Kelvin, proves to be far too short: approximately thirty million years for the Sun. In reality, however, according to reliable geological data, the Sun is of a significantly greater age. From this, it is commonly concluded that there are specific energy sources within stars, akin to accumulators, whose gradual discharge ensures the longevity of stellar lifespans. These sources must release energy according to a certain law depending upon the physical conditions within the star. Consequently, a specific type of energy source will correspond to a certain definite surface within the space of physical conditions under consideration. Under conditions of thermal equilibrium, this quantity of energy must equal the energy expenditure calculated by us above. Consequently, stars can only be situated along the curve of intersection of the two constructed surfaces. In reality, however, stars are distributed within this space not along a curve, nor throughout a volume — which would be the case given major observational inaccuracies — but upon a surface. At the same time, the theoretical curve of intersection of these surfaces should be very sharply defined. Indeed, energy expenditure decreases with an increase in density, whereas energy generation, generally speaking, increases with density. Thus, these surfaces must intersect quite steeply. One is left to conclude that the assumption regarding the existence of energy sources within stars that are independent of the cooling process does not correspond to reality. There are no specific energy sources inside stars, and stars release energy after the fashion of the Helmholtz-Kelvin mechanism of gradual cooling and contraction. Given that the age of stars is significantly greater than their cooling time, we must recognize that, as it loses energy and contracts, a star induces certain processes that compensate for this energy loss. It must be concluded that a star represents a machine that generates energy. However, this mechanism does not operate under all circumstances.

1) Within the space of physical conditions considered by us above, there exists the following fundamental direction, in the vicinity of which the operation of the energy mechanism is possible across a vast range of states (from red supergiants to white dwarfs):

$$\frac{B}{n} = const\,,$$

where B is the radiant energy density, and n is the number of particles cm^3.

If the constant entering here, which has the dimensions of energy, is represented in the form $m_e c_2^2$, where m_e is the mass of an electron and c_2 is a certain velocity, then for c_2 a value of the order of 400 km/s is obtained:

$$\frac{B}{n} = m_e c_2^2\,, \qquad c_2 \cong 400 \text{ km/s} \cong \frac{e^2}{h}\,. \tag{1}$$

In other words, the ratio of B to n must be of the order of the ionization energy of atoms.

2) On sequence (1), when the average distances between particles prove to be of the order of atomic dimensions, a point is obtained (spectral class F_4) around which the majority of stars cluster (the main sequence — subgiants, subdwarfs). In the B and n plane, the clustering of stars is found to be

nearly circular. The position of the center can be determined by adding to (1) the condition:

$$v_p = c_2\,, \tag{2}$$

where v_p is the proton velocity, the concentration of which within stars significantly exceeds the fraction of other elemental nuclei.

3) White dwarfs and massive planets [3] represent celestial bodies wherein matter exists on the borderline of degeneracy. Within these bodies, a specific temperature profile is maintained, preventing complete degeneracy.

From the standpoint of stellar structure theory, the derived conclusions appear anomalous. Nevertheless, they support the fundamental premise that factors preventing a transition to thermodynamic equilibrium operate continuously within the Universe. The present results allow for the extension of this proposition to isolated astronomical bodies. In geodynamics, it has long been established that the evolution of the Earth is governed by a continuous interplay between compressive and expansive forces. This interaction drives the cyclicity of orogeny, which alternates with epochs of relative tectonic quiescence dominated by gravitational compression. The morphologic features of the lunar relief, such as fractures and grabens (e.g., the Alpine Valley), suggest that even small celestial bodies have repeatedly experienced the effects of endogenous factors leading to temporary expansion [4]. Furthermore, a notable correlation exists between these processes and the cyclic variations observed in certain variable stars. Consequently, the hypothesis regarding mechanisms that counteract the degradation of the Universe receives significant validation. Additionally, it is demonstrated that within individual astronomical bodies, resistance to the equilibrium state is mediated by energy release. This leads to the critical inference that inconsistencies in the consequences of the second law of thermodynamics stem from an incomplete formulation of its first law.

To obtain further concrete conclusions, it is natural to turn to the consideration of the above-listed conditions under which the release of energy in stars occurs. Especially characteristic is the first, primary relationship. This relationship is very simple, as it should be for equilibrium processes. For example, the release of heat by freezing water is determined by a simple condition: $T = 0°$C. The amount of energy released in this case depends on more complex circumstances of heat transfer: the thickness of the ice and the temperature of the outside air. Probably, relationship (1) expresses the condition of equilibrium interaction between matter and radiant energy, in which the role of a quantum is played by the average amount of radiant energy per particle; the speed of light c_1, however, is replaced by some other speed c_2. It is completely obvious that this relationship cannot be explained by ordinary electrodynamics and atomic physics.

The second condition under consideration is not directly related to radiant energy, yet it similarly incorporates the velocity parameter c_2. The interplay between these two conditions is highly non-trivial. Specifically, main-sequence stars of spectral classes earlier than F_4, in conjunction with equation (1), constitute a single branch. Stars of later spectral classes constitute a second branch extending in the opposite direction toward condition (3). The mathematical description of these transitions necessitates logarithmic relationships between the physical quantities involved. This ensemble of empirical evidence strongly implies an underlying systemic unity, ruling out mere coincidence. Nevertheless, despite numerous attempts, identifying a unifying principle has not yet been possible. The analyzed results appear to be complex consequences of a more fundamental and simpler underlying cause. The physical essence of this phenomenon must be directly linked to the central conclusion that a star functions as an energy-generating thermodynamic system.

The nature of conditions (1), (2), and (3) indicates that energy generation in stars is driven by certain electrodynamic processes. However, the fundamental principle that allows a closed system to generate energy must be sufficiently universal to manifest within the basic laws of mechanics. Consequently, priority must be given to the following questions: what is the physical mechanism of energy generation within a closed mechanical system, and what constitutes the source of this excess energy?

For the sake of simplicity, we shall assume that the particles of a closed system describe closed trajectories as well. All forces acting upon the particles lead to the law of conservation of energy. Therefore, they can be considered as accounted for, and the motions of the particles can be viewed as occurring in ordinary Euclidean space. From the equivalence of all points of space, it follows that the difference in trajectories cannot lead to a difference in the mechanical properties of the particles. Consequently, it is sufficient for us to consider any identical trajectories, for example, circles. In this case, motions are possible in two opposite directions, which we shall define with respect to a certain mechanical reference point, such as a force acting along the axis of the circle. The resulting two complexes cannot be made to coincide by a rotation of the coordinate axes. For this, a change in the sign of time or a mirror reflection is required.

If the laws of true mechanics are asymmetric with respect to the specified transformations, then the mechanical properties of our two complexes must also be different. Since kinetic energy cannot depend on the direction of rotations, only the potential energies of these complexes must be different. Therefore, the total energy is not conserved, and an engine producing energy must prove to be fundamentally possible.

The asymmetry of the laws of mechanics with respect to mirror reflections can have a direct astronomical verification. Indeed, the hemispheres of planets, divided by the equatorial plane, are complexes having different rotations with respect to gravity. If these hemispheres have different mechanical properties, then the figures of the planets must turn out to be asymmetric with respect to the equatorial plane. Our measurements of the figures of Jupiter and Saturn, compared with geodetic data on the figure of the Earth, indeed showed an asymmetry: for all planets, the Southern Hemisphere turned out to be more elongated than the northern one [5]. This result directly contradicts the laws of ordinary mechanics and indicates its asymmetry.

The asymmetry of the laws of mechanics can mean only one thing, that time possesses some asymmetric property associated with the non-equivalence of the real World and its mirror reflection. This property of time can be called directionality or the course. Now it can be said that the existence of the directionality of time follows from astrophysical data. By virtue of this directionality, time can perform work and produce energy. Thus, a star is only an apparent perpetuum mobile: a star draws energy from the course of time.

Apparently, inside stars, a compensation occurs not only for the loss of energy, but, under certain circumstances, for the loss of angular momentum as well. A ground for such a conclusion can be provided by the lack of synchronism between the orbital and axial rotations of close spectroscopic binary stars, observed in a number of cases. However, synchronization of these rotations must occur within relatively short timeframes due to tidal forces, given the inevitable turbulence. Thus, it is highly probable that the course of time can not only increase the energy of a system, but can also increase its momentum.

What time itself represents is still unknown. In physics, vague reflections on this matter exist, whereas, by virtue of the importance of the question, entire volumes should have been written about time. The physicist knows how to measure only the duration of time; therefore, for him, time is a completely passive concept. Now we have come to the conclusion that time possesses other, active properties as well. Time is an active participant in the Universe.

This marks the end of the inductive part of our investigation. In the future, we may not rely on the presented argumentation. In the next Chapter, we shall endeavor to substantiate and refine the concept of the course of time, using only the most general notions of the World that follow from the experiments of all natural science and the experiences of life.

Chapter II. Basic principles of causal mechanics and their kinematic consequences

> "Science of the 20th century is at a stage where the moment has come to study time, just as matter and energy filling space are studied."
>
> *Prof. V. I. Vernadsky* [6]

There is a profound difference between natural science and the so-called exact sciences — mechanics and physics. A natural scientist constantly asks the question "Why?" — what is the cause of the observed phenomena. The experience of natural sciences and everyday life convinces us that this question is legitimate, and that there must always be an answer to it. Such is the property of the World called causality. Thanks to this property, the cognition of nature is possible. Causes must differ from effects, otherwise they could not be found. This principle of natural science is completely opposite to the principle of exact sciences.

The essence of the laws of mechanics is expressed by the ancient formula "*Causa aequat effectum*", on which R. Mayer based the deduction of the law of conservation of energy. Therefore, although mechanics uses the concepts: action and reaction, active and passive forces, it immediately makes a reservation that there is no difference between these concepts. The consistent implementation of this principle of equivalence of cause and effect should have completely excluded the possibility of answering the question "why?" in the exact sciences. Therefore, the exact sciences answer only the question "How?" — in what manner a given chain of phenomena occurred.

As a result, the exact sciences, transforming into independent disciplines, had to increasingly become descriptive sciences. The description is carried out by physical laws, the exact formulation of which allows for the extensive use of a rigorous mathematical apparatus. In this rigor of description lies the power of the exact sciences. Of course, physical laws express the causal connection of phenomena existing in the World. But when the fundamental impossibility of distinguishing causes from effects is postulated, then the existence of laws cannot be an object of study, and the laws turn into formulas describing phenomena.

Theoretical physics of our century grew on the basis of these views and represents a vivid example of a descriptive exact science. The logical and consistent development of the principle of equivalence of causes and effects of the exact sciences led Mach to the construction of his philosophy. The mere incompatibility of this philosophy with the entire essence of our World can serve as proof of the inadequacy of the principles of exact sciences.

The question "Why?", which constantly arises before the natural scientist, forces them to seek ever deeper principles encompassing as wide a range of phenomena as possible. In the final analysis, these principles must express the basic properties of matter, space, and time, and therefore be principles of mechanics. The attempt of eighteenth-century scientists to explain even the phenomena of life by the principles of mechanics was completely natural and logical. It is well known that this attempt was a complete failure. At the same time, this mechanistic approach is incorrect not in its essence, but only because the principles established by mechanics are incomplete and insufficient to explain the phenomena of the World. Life by itself cannot endow matter with fundamental properties that it does not possess outside of organisms. Those properties of matter that play a primary role in the processes of life may be barely noticeable in simple mechanical experiments. However, these properties must be revealed by precise, specialized investigations and must be provided for by the laws of mechanics. Wherein the incompleteness of the laws of mechanics lies seems perfectly clear: the laws of mechanics do not express the basic property of causality, which consists in the fundamental difference between causes and effects. True mechanics must be a causal mechanics, i.e., it must contain a principle that allows one to distinguish cause from effect by some mechanical experiment. Thus, the foundation of mechanics must be laid upon the axiom:

I. In causal relationships, there is always a fundamental difference between causes and effects. This difference is absolute, independent of the point of view, i.e., of the coordinate system.

The core concept of causal mechanics must be the concept of force, since force is the cause of a change in the state of bodies. In conventional mechanics, it turns out to be possible to replace the concept of force with another concept — energy, which significantly simplifies mechanics. This replacement, fully implemented in atomic mechanics, completely eliminates the distinction between causes and effects, and therefore leads to a statistical interpretation of the phenomena of the World. Causal mechanics, however, being based on the difference between causes and effects, must be a mechanics of forces, rather than energies.

In conventional mechanics, the causality of phenomena is expressed by Newton's third law of the equality of action and reaction. According to this law, a change in the momentum of a body cannot occur under the action of internal forces, i.e., an external force cannot arise in a body without the participation of another body. Only another body can be the cause of a mechanical effect. From the point of view of mechanics, the basic property of bodies is impenetrability, i.e., the impossibility for bodies to occupy the same part of space simultaneously. Therefore, causes and effects, being always associated with different bodies, must necessarily be associated with different points in space as well. From this follows the basic property of causality:

II. Causes and effects are always separated by space. The distance between a cause and an effect can be as small as desired, but it cannot be equal to zero.

The existence of an effect at some finite distance from a cause is the result of a long chain of cause-and-effect transformations. The cause, i.e., the force, in the form of the momentum of a moving point, is transferred from one point of space to another, where it can produce an effect that becomes the cause of changes in subsequent points. As a result of this relay, the effect may end up at some finite distance from the initial position of the cause. This process of momentum transfer is described by conventional mechanics. We, however, will be interested in that elementary link in the cause-and-effect chain where the transformation of cause into effect takes place. The non-trivial meaning of axiom II lies in the fact that it fully applies to this direct transformation of cause into effect as well. Indeed, since causes and effects cannot be superimposed, there must exist some spatial distinction between them, which we shall denote by the symbol δx. From the point of view of mathematical analysis δx is the size of a point and must be considered equal to zero during conventional mathematical operations, for instance, when calculating the length of the entire cause-and-effect chain. To express the condition of the impenetrability of material points, we are forced to use this concept, even though it has not been mathematically developed. The physical meaning of this concept allows us to view δx as an interval of a higher order of smallness than the infinitesimally small space interval in analysis. From a mathematical point of view, this approach is completely non-rigorous, but it is dictated by the physical meaning of the problem under consideration.

Cause and effect are always associated with different material points; therefore, Proposition II is a necessary condition. This circumstance should be emphasized by a special proposition:

III. Causes and effects arising at the exact same point in space cannot be distinguished and represent identical concepts.

For example, Newton's second law asserts the equality of force to the change of momentum per unit of time. It might seem that force should be considered as the cause, and the change of momentum as the effect of this cause. However, according to Proposition III, one cannot make such a distinction. These concepts are identical, and, as Kirchhoff did in his mechanics, the change of momentum of a material point per unit of time can serve as the definition of the force applied to this point. Thus, Newton's second law should be viewed as a descriptive law, as a formula describing a phenomenon.

In conventional mechanics, using Proposition II alone, it is impossible to establish a difference between cause and effect. This stems from the circumstance that the sign of δx depends on the reference frame and is completely arbitrary. Now we must find the circumstance that establishes an absolute difference between causes and effects in the World. Despite the great successes of natural science and philosophy, we cannot strictly define what causes and effects, or the future and the past, actually are. We only know that these concepts are interconnected: the effect is always in the future with respect to the cause. Thus, the difference between causes and effects is established by the property of time.

From the circumstance that the effect is in the future with respect to the cause, there follows, first of all, the next proposition, which is fully analogous to Proposition III:

IV. Causes and effects are always separated by time. The time interval between a cause and an effect can be as small as desired, but it cannot be equal to zero.

In a full chain of cause-and-effect transformations, when the effect appears at a finite distance Δx from the cause, the effect arises after the cause through a finite time interval Δt. The ratio of these quantities $\Delta x/\delta t$ determines the speed of signal propagation, which, according to the special theory of relativity, cannot exceed the speed of light c_1. In each elementary link, where the cause and the effect are separated by an element of space δx, an element of time difference δt must also exist. The concept of δt is in every way completely similar to the concept of δx. In other words, δt represents a point in time, which, due to the existence of the distinction between cause and effect, we cannot consider to be equal to zero. If, for example, the cause arises at the very end of the first second, then the effect arises at the very beginning of the second second, and so on. To calculate the time interval in a full cause-and-effect chain, we will act with perfect accuracy if we set the sum of all δt equal to zero and calculate only the time of the momentum propagation. Thus, by introducing the quantities δx and δt, we do not alter conventional calculations of the momentum propagation speed in the slightest.

Proposition IV is based on the existence of the simplest property of time, which can be called scalar or passive. This property makes it possible to establish the duration of events or the length of time intervals measured by clock readings. The basic concepts of kinematics —velocity, acceleration, and others — are defined precisely through this property of time.

However, this property of time cannot establish the difference between cause and effect. Indeed, just as in the case of space, the sign of a time interval depends on the chosen reference frame and is therefore completely arbitrary. It must be noted that the system of time reckoning cannot be fixed by the direction of entropy either.

Indeed, the transition of a mechanical system into a more probable state, i.e., an increase in entropy, occurs due to the continuous fragmentation of causes taking place in the Universe: causes transform into effects, which become the causes of other effects, and so on. Therefore, this system of time reckoning, being itself based on the definition of causes and effects, cannot yield anything new and leads to a tautology: the future is where the effect is, that is, where the future is.

Since the time of Newton, it has been generally accepted in theoretical mechanics and physics that time possesses only one passive property. However, from the existence of the distinction between causes and effects, we are forced to conclude that time has yet another, special property. This property of time lies in the distinction between the future and the past, and it can be called directionality or the flow of time. Our psychological sensation of time is precisely the perception of the flow of time objectively existing in the Universe.

It is highly interesting that Prof. V. I. Vernadsky, in his generalizations on the problems of natural science, arrived at the following conclusion: "*. . . the time of the naturalist is not the geometric time of Minkowski, nor is it the time of mechanics and theoretical physics, chemistry, Galileo, or Newton*" [6]. We see that these words are profoundly true. Indeed, for the naturalist, as in everyday life, the primary significance belongs to the directionality of time — a concept that has been completely unused by the exact sciences. Now we can formulate the following proposition:

V. Time possesses a special, absolute property that distinguishes the future from the past, which can be called directionality or the flow. This property determines the distinction between causes and effects, for effects are always in the future with respect to causes.

This last proposition introduces a new physical concept into mechanics — the flow of time. The properties of this concept must be thoroughly studied through experiment. However, in order to know how to set up an experiment, it is necessary to already have some general understanding of this new concept. Let us now show that a number of properties of the flow of time can be logically derived from the analysis of our formulated axioms of causality.

It is to be expected that the flow of time of our Universe is determined by some universal constant of a specific sign. Under a different flow of time, this constant must be different and may even have a different sign. The flow of time must be determined with respect to some invariant. From our axioms, it follows that the flow of time can be determined with respect to space.

Indeed, from a comparison of the second and fourth axioms, we conclude that the future and the past are always separated by an infinitesimally small, yet non-zero interval of space. Thus, the directionality of time can be defined as a direction in space. From the third and fourth propositions, it follows that the difference between the future and the past δt tends to zero as $\delta x \to 0$. This implies the existence of a relationship between δt and δx, which, for a sufficiently small δx, must take the form:

$$\delta t = \frac{1}{c_2}\,\delta x\,. \tag{3}$$

Since the difference between the future and the past is expressed in units of time, c_2 represents a constant having the dimensions of velocity. The subscript "2" of the course-of-time constant is used to distinguish this constant from the velocity of light c_1, which, according to the special theory of relativity, is the fundamental characteristic of scalar time. The constant is, as it were, the velocity of the transformation of cause into effect and can serve as a measure of the course of time. We shall call the quantity c_2 itself the course of time, rather than its reciprocal: the greater c_2, the smaller the time interval corresponding to the same spatial interval, and, consequently, the faster time flows.

From Proposition V, it follows that the course of time must be determined by a universal constant. Therefore, the constant c_2 must not depend not only on the coordinates of points and the moment when the phenomena occur, but also on the physical properties of the bodies with which the cause and effect are associated. Proposition V further asserts that the course of time has a definite sign, invariant for the entire

Universe. Thus, the constant c_2 must have a definite sign, independent of the reference system of δx and δt. In other words, an invariant coordination of signs is required in formula (3). The signs of δx and δt entering formula (3) are completely arbitrary and, moreover, cannot depend on each other. This follows, for example, from the fact that with a possible absolute difference in the signs of δt, there can be no absolute difference in spatial directions, that is, in the signs of δx, since space has no properties. Therefore, the coordination of signs in formula (3) is possible only in the case when the sign of c_2 also changes with a change in the sign of δt or δx. To reconcile the change in the sign of c_2 with a change in the sign of δx under the condition of invariance is possible in only one way: the constant c_2 must be a pseudoscalar, i.e., a scalar that changes its sign when passing from a right-handed coordinate system to a left-handed one and vice versa. In this case, δt must be a pseudovector.

From Proposition V, it follows that the course of time must be determined by a universal constant. Therefore, the constant c_2 must not depend not only on the coordinates of points and the moment when the phenomena occur, but also on the physical properties of the bodies with which the cause and effect are associated. Proposition V further asserts that the course of time has a definite sign, invariant for the entire Universe. Thus, the constant c_2 must have a definite sign, independent of the reference system of δx and δt. In other words, an invariant coordination of signs is required in formula (3). The signs of δx and δt entering formula (3) are completely arbitrary and, moreover, cannot depend on each other. This follows, for example, from the fact that with a possible absolute difference in the sign of δt, there can be no absolute difference in spatial directions, that is, in the sign of δx, since space has no directional properties. Therefore, the coordination of signs in formula (3) is possible only in the case when the sign of c_2 also changes with a change in the sign of δt or δx. To reconcile the change in the sign of c_2 with a change in the sign of δx under the condition of invariance is possible in only one way: the constant c_2 must be a pseudoscalar, i.e., a scalar that changes its sign when passing from a right-handed coordinate system to a left-handed one and vice versa. In this case, δt must be a pseudovector.

Let us show that formula (3) will not depend on the system of time reckoning δt, provided that δt is a pseudovector orienting the plane perpendicular to the cause — effect axis. Indeed, let us change the direction of the X-axis in formula (3), i.e., the sign of δx while preserving the orientation of the (YZ) plane, and consequently, the sign of δt. Since the type of the coordinate system has changed in this process, the pseudoscalar c_2 must change its sign, and both sides of equality (3) will remain consistent. Now let us rotate the entire coordinate system so that the direction of the X-axis is reversed. Then the orientation of the (YZ) plane will change to the opposite, i.e., the sign of δt and, as seen from formula (3), c_2 will not change its sign. Just so, with the direction of the X-axis remaining unchanged, by reversing the reckoning of time, we change the orientation of the (YZ) plane and, consequently, the sign of the pseudoscalar c_2. Thus, proceeding from the axioms of causality, we have arrived at the following fundamental conclusion:

1. The world course of time is determined by a universal pseudoscalar c_2 having the dimension of velocity.

Theoretical mechanics and physics use scalar quantities of the first kind only, or simply scalars. Now we must introduce the pseudoscalar c_2 into mechanics. Turning to the known universal constants, we are immediately convinced that the Planck constant h is the only constant that can be considered a pseudoscalar. Indeed, this constant, having the dimension of angular momentum, determines the spin of elementary particles and all angular momenta in an atom. To satisfy the quantum conditions during the transition from a right-handed to a left-handed coordinate system, it is natural to assume that the sign of the Planck constant also changes during such a transition, i.e., that it is a pseudoscalar. Now, using h and another physical constant known to possess the properties of a simple scalar, one can form a constant with the dimension of velocity. It is easy to verify that the existing choice leads to a unique combination that unambiguously determines the pseudoscalar c_2:

$$c_2 = \alpha \frac{e^2}{h} = \alpha \times 350 \text{ km/s}, \tag{4}$$

where e denotes the charge of an elementary particle. The numerical coefficient α represents a dimensionless factor within the accuracy of which we have determined the value of c_2. It should be expected that the inaccuracy associated with this dimensionless factor cannot change the order of magnitude of c_2. In fact, from the experiments to be discussed later, it can be concluded that $\alpha \cong 2$. It is highly significant that the constant numerically equal to c_2 determines conditions (1) and (2) of energy production in stars. The famous dimensionless fine-structure constant turns out to be the ratio of c_2 and c_1, i.e., the ratio of the basic characteristics of the two properties of time. With this understanding of the fine-structure constant, the existence of this dimensionless constant becomes natural and completely unsurprising. The obtained estimate of the value of c_2 (4) allows us to foresee the magnitude of the effects of causal mechanics, which must be many orders of magnitude greater than the effects of the theory of relativity.

Let us perform the limiting transition $h \to 0$ in formula (4); then $c_2 \to 0$ and, according to formula (3), δt will always be equal to zero. This case corresponds to ordinary mechanics, which lacks the fourth axiom, i.e., δt is always assumed to be equal to zero. Thus, by neglecting the Planck constant, we transition to the laws of ordinary mechanics, just as is done in atomic mechanics. Another limiting case is obtained when the Planck constant begins to play a very significant role. This case corresponds to atomic mechanics, for which formula (4) yields $c_2 = 0$. In this process, according to formula (3), δx is always equal to zero. In this case, according to Axiom III, causes and effects merge into identical concepts, which constitutes the very essence of atomic mechanics.

2. The world course of time c_2, within the accuracy of a dimensionless factor of the order of unity, equals the universal pseudoscalar e^2/h, which has the dimension of velocity. The sign of the course of time must be determined by experiment.

Let us show that the sign of the course of time allows us to absolutely define the concepts of right and left. Geometry distinguishes right from left only relatively, and geometry by itself cannot define what is called right and what is called left. Let us clarify this with the following example borrowed from Gauss. Imagine two beings isolated to such an extent that there is not even a single object that they both have ever seen. Suppose that they can communicate their thoughts and their observations of the World to each other. Each of them can construct a system of geometry, and they will be able to agree upon and reconcile all geometric definitions. They will discover that there exist incompatible bodies with identical elements, and thus they will arrive at the necessity of distinguishing right from left. However, they will not be able to reconcile their definitions of right and left. For this purpose, a common body is necessary, i.e., a material bridge between them. This will be the state of affairs as long as our imaginary beings engage only in geometric constructions. But as soon as they proceed to the study of mechanical and other natural phenomena, thanks to the course of time they must discover an objective distinction between right and left and be able to agree on their definition. Indeed, as we have seen, the laws of mechanics must contain the pseudoscalar c_2. Therefore, by performing certain experiments, one can establish the sign of c_2, i.e., determine in which coordinate system — right-handed or left-handed — the constant c_2 has a positive value. This yields the possibility of agreeing on the definition of right and left. Thus, the existing course of time connects all bodies in the World, even under complete isolation, and plays the role of that very material bridge, the necessity of which Gauss spoke about. Therefore, we can formulate the following conclusion:

3. The course of time existing in the World establishes an objective distinction between right and left in space.

It is a striking circumstance that there actually exist conspicuous, objective distinctions between right and left in nature. These distinctions have long been known in the organic world. The morphology of animals and plants provides numerous examples of persistent, hereditary asymmetry. For instance, in the overwhelming majority of cases, the shells of mollusks are coiled to the right. A predominance of a certain symmetry is also observed in microbes that form colonies of spiral structure. In highly organized beings, the asymmetrical position of organs is always repeated [8]. For example, the heart in vertebrates is, as a rule, located on the left. A similar asymmetry exists in plants; for instance, in the preference for left-handed spirals in conducting vessels.

In the middle of the last century, Louis Pasteur discovered the asymmetry of protoplasm and, through a series of remarkable studies, demonstrated that asymmetry is a fundamental property of life. In inorganic nature, stereoisomers form racemates, i.e., mixtures with an equal number of right-handed and left-handed molecules. In protoplasm, however, a stark inequality of right-handed and left-handed forms is observed. The effect of right-handed and left-handed isomers on an organism is often very different. Thus, for example, left-rotatory glucose is almost not assimilated by the organism, left-handed nicotine is more poisonous than right-handed nicotine, etc. Currently, all these questions constitute a major scientific problem, upon which we cannot dwell [9]. For us, the fundamental aspect of the matter is important: asymmetry can have physical meaning only if there is a directionality of time; therefore, the asymmetry of life proves the existence of the directionality of time, i.e., the non-symmetry of true mechanics. The existence of the directionality of time as a certain physical reality follows even simply from the very possibility of life. Indeed, the essence of life lies in processes directed against the increase of entropy. This means that in organisms, during certain processes, the course of time may differ from the world course of time. Therefore, similarly to astrophysical data, precise biological experiments must reveal in life processes a violation of the usual energy balance due to the utilization of the world course of time by life.

Let us also consider the following question: what must a World be like in which the flow of time is opposite to ours? To change the sign of the course of time means to change the sign of the constant c_2 in that same coordinate system. Since the laws of mechanics must be identical as long as c_2 has the same sign and the same value, the mechanics of a World with a reversed flow of time must be identical to the mechanics of our World with an opposite orientation of coordinates. An opposite orientation is obtained by mirror reflection. Thus, we arrive at a theorem that expresses the essence of our mechanics:

4. A World in which the flow of time is opposite to ours, provided that the same forces act, must be equivalent to our World reflected in a mirror.

Causality is completely preserved in a mirror-reflected World. Therefore, in a World with a reversed flow of time, events must develop just as regularly as in our World. Under any flow of time, a person will walk, as usual, face forward. Thus, a World with a reversed flow of time is not, as is often thought, a motion picture of our World run backward. Indeed, in such a motion picture, causality is violated, and it cannot represent a realistically possible physical World. Due to the directionality of time, a mirror-reflected World must differ from our World in its mechanical properties. Imagine that we are observing through a mirror a laboratory in which certain mechanical experiments are being performed. The mirror is crafted so skillfully that we cannot suspect it. However, by following the results of some special experiments in the laboratory, we will have to notice that they are opposite to the consequences of causal mechanics. Thus, we will always have an opportunity to distinguish a genuine laboratory from a laboratory reflected in a mirror. Ordinary mechanics, on the other hand, asserts the impossibility of such a conclusion. The fallacy of this principle has now been proven by the research initiated by Lee and Yang, which established the violation of the principle of parity conservation in nuclear processes during weak interactions. Taking into account the processes of life, this principle is refuted by elementary observations. Indeed, by following the individuals performing experiments in the reflected laboratory, one can immediately notice that they work with their left hand and have an unusual arrangement of organs, and therefore are not real. One must think that we would become such people under a reversed flow of time, provided only that the force fields of our World are preserved.

After the digression made, let us return to the clarification of further properties of the course of time. All cause-and-effect relationships of the World are characterized by a universal pseudoscalar c_2. Every specific cause-and-effect relationship is also determined by a spatial direction, the unit vector of which we shall denote by i. Thus, pseudovectors of the course of time ic_2 must be associated with cause-and-effect relationships.

The circumstance according to which the course of time is determined by pseudovectors can have the following further explanation. The vectors of the course of time must be directed in a certain way depending on the position of the cause and the effect. Let us imagine now that the course of time in the entire World has reversed its sign to the opposite, while the arrangement of causes and effects in space has remained unchanged. From the first condition, it follows that these vectors must change their signs; from the second, however, that they have retained their direction. Geometry provides the only possibility of reconciling these requirements: the course of time represents a pseudovector, and during changes in the sign of the course of time, we simply must use a different type of orientation of coordinate systems.

Let us prove now that for a cause and an effect, the pseudovectors of the course of time ic_2 must have different signs, i.e., be directly opposite. Indeed, the effect is located in the future with respect to the cause, and the cause is in the past with respect to the effect. Therefore, the signs of δt for the cause and the effect must be opposite. In other words, by transferring the point of view from the cause into the effect, we change the sign of δt, i.e., we pass to the opposite orientation of the plane perpendicular to the "cause-effect" axis. Now it is easy to be convinced that, by whatever way the unit vector i is determined, the pseudovector ic_2 must change its sign during the transition from the cause to the effect. Indeed, with a fixed i, the type of coordinate system will change during the transition from the cause to the effect. As a result, the constant c_2 must change its sign, and consequently, the vector ic_2 will too. If, however, during the transition from the cause to the effect, the sign of i is changed, then the sign of c_2 will remain unchanged. Therefore, in this case as well, the pseudovector ic_2 will change its sign. From this, the conclusion is obtained:

5. The course of time of each cause-and-effect relationship is a real physical process, which is represented by a pseudovector ic_2 having opposite directions for the cause and the effect.

Therefore, time possesses the following two properties: 1) a scalar property, which is expressed by the existence of time intervals $|\Delta t|$, and 2) a vector property, which is represented by the pseudovectors of the course of time $\pm ic_2$. The course of time as a real physical process, leading from the point of view of the cause to the existence of a pseudovector of one sign, and from the point of view of the effect to a pseudovector of the opposite sign, is equivalent to the rotation of the cause relative to the effect with a linear velocity c_2, or vice versa. This explanation, while formal, is absolutely precise. However, a natural question arises: what is the essence of this phenomenon, and how can one visually imagine the rotation of two admittedly stationary points with a finite linear velocity? To this question, we cannot answer now. But one can hope that this phenomenon will become clearer as a result of experimental and subsequent theoretical investigations. Therefore, for now, we can only use the formal representation of the course of time as the relative rotation of causes and effects.

Let us imagine that the cause and the effect are connected with two material points actually in relative rotation. In other words, let us assume that we are dealing with gyroscopes, which we shall consider ideal. By an ideal gyroscope, one should understand a body whose entire mass is located at some constant distance from the axis. Upon rotation, the action of such a body on a body rotating at a different speed can be carried out through a material axis and material connections with this axis, the masses of which are so small that they can be assumed equal to zero. Then the interaction of these ideal gyroscopes will be equivalent to the interaction of two points having the masses of the gyroscopes. From the point of view of each of these points, one can speak with complete certainty about the rotation of the other point, i.e., specify the plane, the magnitude of the linear velocity u, and the direction of rotation. Thus, a pseudovector of relative rotation ju can be associated with each point, where j is a unit vector perpendicular to the plane of rotation. According to the usual convention, in a right-handed coordinate system, the pseudovector ju is directed toward the side from which the rotation appears to occur counterclockwise. One can consider j to be an ordinary vector, and the magnitude of u to be a pseudoscalar. If, for example, we agree to plot j, regardless of the type of coordinate system, toward the side from which the rotation occurs counterclockwise, then u will be a pseudoscalar, positive in a right-handed coordinate system. It is easy to see that as a result of relative rotations, additional pseudovectors $\pm\, ju$ of opposite signs will exist for the cause and the effect. These pseudovectors have exactly the same properties as the pseudovectors $\pm\, ic_2$ of ordinary cause-and-effect relationships. In any case, in the linear approximation, such quantities are usually added together. Therefore, one can assume the following property of the course of time, which must be verified experimentally:

6. The course of time of rotating bodies differs from the ordinary course of time in that the relative linear velocity of these rotations is geometrically added to the ordinary course of time.

If this proposition holds true, then for rotating bodies, one should expect a relative change in the direction of the ordinary pseudovector of the course of time by the magnitude $(u/c_2)\cos\alpha$, where α is the angle (i, j). One should also expect an aberration of the direction of the cause-and-effect relationship by the angle ψ:

$$\tan\psi = \frac{u}{c_2}\,\sin\alpha.$$

Now it becomes clear that in order to clarify the properties of the course of time, it is necessary to conduct experiments with rotating bodies — gyroscopes. To understand what mechanical effects of the course of time should be observed in experiments with gyroscopes, we must first of all refine the definitions of causes and effects in mechanics. For this purpose, it is necessary to proceed from kinematic concepts to the concepts of dynamics and statics.

Chapter III. Some deductions of causal dynamics and statics

Forces are the causes that produce changes in the configuration and changes in the momentum of bodies. A change in the relative position of bodies results in the appearance of deformation forces. A change in momentum per unit time taken with the opposite sign can, according to d'Alembert, be considered as an inertial force, the addition of which to ordinary forces reduces the problem of dynamics to a problem of statics. Under such a representation, the forces acting on a system are always balanced, and the addition of new forces must necessarily cause the appearance of certain other forces. Therefore, in mechanics, forces can be considered both as causes and as all possible effects. In accordance with conventional terminology, causes will be called active forces. Let us assume that active forces are applied to some material point (1), the resultant of which we shall denote by A. The action of these active forces can be transmitted to another point (2). This action of force A on point (2), i.e., the passive force arising at point (2) due to the force A applied to point (1), will be denoted by Φ. It can be said that point (1) is the cause of the force arising at point (2). According to Conclusion 5 of the previous Chapter, a pseudovector of the course of time ic_2 corresponds to this cause-and-effect relationship at point (2). Thus, the force Φ turns out to be associated with the pseudovector ic_2. However, this pseudovector must necessarily be accompanied by the pseudovector $-\,ic_2$ for the cause, i.e., at point (1). Therefore, at point (1) we must have the same result, i.e., the same force as at point (2), but acting only in the opposite direction. This yields the conclusion:

1. When the first point acts on the second, the pseudovectorial course of time necessarily establishes a counteraction, i.e., an equal and oppositely directed action of the second point on the first.

This conclusion coincides with Newton's third law. Thus, Newton's third law follows from the properties of the course of time. Using this law, we can determine the magnitude of action Φ that interests us, proceeding from the condition of equilibrium of point (1):

$$A + R - \frac{dm_1 v}{dt} = 0\,, \tag{5}$$

where R is the reaction force, i.e., the counteraction of point (2) on point (1). In the case of pure statics: $R = -\,A$ and, according to Newton's third law, $\Phi = A$.

In dynamics, a question arises as to whether the inertial force $-\frac{dm_1 v}{dt}$ should be considered an active or a passive force. The inertial force, directed against active forces, arises only due to these forces; therefore, it does not differ from active forces and must be added to them. In this case, we obtain $\Phi = A - \frac{dm_1 v}{dt}$. From this, for the free motion of point (1), we obtain an obvious result: $\Phi = 0$, i.e., the absence of action on other points. If now the inertial force is directed against the reaction force, then it is caused by these forces, does not differ from them, and must be added to them. Therefore, the reaction to the active force will not be R, but the expression: $R - \frac{dm_1 v}{dt} = -A$. Consequently, the action of the active force on point (2) will be the same as in statics: $\Phi = A$. Let us write down these conclusions in the following form:

$$\left.\begin{aligned} &|A| \geqslant |R|\,, \qquad \Phi = A - \frac{dm_1 v}{dt} \\ &|A| \leqslant |R|\,, \qquad \Phi = -\left(R - \frac{dm_1 v}{dt}\right) = A \end{aligned}\right\}. \tag{6}$$

From these formulas it follows that when the active forces are equal to zero ($A = 0$), the effects are also equal to zero ($\Phi = 0$). Therefore, in the collision of two spheres upon which no external forces act — meaning that causes are absent — effects must also be absent, despite the existence of reactions. Active forces can also be applied to point (2). Then the action of these forces on point (1) can be calculated using the same expressions (6) written for point (2). Let us now turn to the question of aligning action and reaction with the pseudovectors of the course of time. According to formulas (6), the direction of action coincides with the line connecting causes and effects, i.e., with the spatial orientation of the time pseudovectors. On the other hand, the course of time must point toward the future, and therefore must coincide with the direction of action of the active force, the unit vector of which we shall denote by i. Then the course of time at point (2), i.e., the vector ic_2, will be aligned with the action of the force, provided that we use a coordinate system in which the pseudoscalar c_2 has a positive value. This alignment of ic_2 and Φ means that

$$\Phi = ic_2 |J| , \tag{7}$$

where $|J|$ is a certain positive scalar coefficient. At point (1), ic_2 changes sign, and according to formula (7), the reaction force $R = -\Phi$ will act on this point. With stopped time, i.e., when $c_2 = 0$, the actions of all forces must be absent. This result is obtained directly from formula (7). Therefore, the scalar coefficient $|J|$, at least in the first approximation, must be invariant, i.e., independent of the course of time.

Let us consider the case where point (1), upon which an active force acts, represents an ideal top rotating with a speed ju relative to point (2). As was indicated at the end of the previous Chapter, for definiteness, the unit vector j can be considered directed along the axis toward the side from which the rotation appears to occur counterclockwise, if one uses a coordinate system fixed to the second point. Then u will be a pseudoscalar, positive in a right-handed coordinate system.

Let us begin investigating the question of the action of a top on a non-rotating body from the simplest case, when the axis of the top coincides with the line of action of the force. An example can be the action of a heavy top with a vertical axis on a fixed support. In this problem, the pseudovectors $\pm ju$ are completely analogous to the pseudovectors of the course of time $\pm ic_2$. Therefore, in the system under consideration, the course of time must be the quantity: $\pm(ic_2 + ju)$. Substituting this expression instead of ic_2 into formula (7), we find:

$$\Phi_u = (ic_2 + ju)|J| .$$

Since $|J| = |\Phi|/c_2$, we finally have:

$$\left.\begin{aligned} \Phi_u &= \Phi + j\frac{u}{c_2}|\Phi| \\ R_u &= R - j\frac{u}{c_2}|\Phi| \end{aligned}\right\} . \tag{8}$$

Under the action of the additional forces $\pm j(u/c_2)|\Phi|$, the equilibrium of the system will be disturbed. A new equilibrium of the top will be obtained when, as a result of the displacement of the points of the top, the elastic forces begin to give a reaction R', at which

$$R'_u = R' - j\frac{u}{c_2}|\Phi| = R .$$

Thus:

$$R' = R + j\frac{u}{c_2}|\Phi| . \tag{9}$$

The elastic forces that determine the reaction are a consequence of gravity. Their change can be caused only by a change in the cause or in the weight of the top. Therefore, the observed elasticity means that the active force has changed and become equal to $A' = -R'$. Then from formula (9) it follows:

$$A' = A - j\frac{u}{c_2}|\Phi| . \tag{10}$$

This active force will exert an action on the support:

$$\Phi' = \Phi - j\frac{u}{c_2}|\Phi| .$$

Substituting this value of action instead of Φ into formula (8), we find that the total action on the support remains the same:

$$\Phi'_u = \Phi' + j\frac{u}{c_2}|\Phi| . \tag{11}$$

From the obtained formulas of force transformation (9)–(11), the following conclusion follows:

2. When a heavy rotating top acts on a support, its weight changes with a corresponding change in deformation. The action of the top on the support, however, remains the same.

This effect can be clearly visualized in the following way. Let us imagine an infinite number of weightless springs connected to a support and acting upon each material point of a top in the direction of the axis of rotation. Depending on whether the springs are stretched or compressed, an increase or decrease in the weight of the top will occur, which, however, cannot be detected by conventional weighing, since the pressure of the top on the balance pan will remain unchanged. This invariability of the action of a heavy top on a support is due to the fact that Newton's third law, which follows from the two-sided nature of the pseudovectors of the course of time, is satisfied during rotation. This two-sided nature is also preserved during rotation. Thus, the course of time cannot alter the total momentum of a system, i.e., it cannot create an external force with respect to the cause-and-effect system. The forces arising due to the course of time are always internal, equal, and oppositely directed forces. This proposition is so important that we deemed it necessary to confirm it with precise experiments, which will be described in detail in Chapter V. Let us now indicate only the general substance of these experiments and the result obtained.

The first experiment consisted in weighing a top on a beam balance at rotation velocities of $u \cong 50$ m/s. If, contrary to our conclusions, the action of the top on the weights were to change during rotation, the relative effects of the course of time would have to be of the order of u/c_2, i.e., of the order of 10^{-4}, or amount to at least several units of the fifth decimal place. Experiments showed that the force acting on the balance during rotation did not change to an accuracy of one millionth. It is important to note that during these experiments, when the suspension transmitted the vibrations of the top to the balance beam, very interesting effects of changes in the balance readings were noticed, which depended on the direction of rotation. These observations convinced us for the first time of the existence of mechanical effects of the course of time. Since the observed effects were associated with the vibrations of the top, we deemed it necessary to set up an experiment of weighing a moving top on an elastic suspension. The balance readings during the drops and lifts of the rotating top turned out to be invariable. This experiment establishes with particular clarity the validity of the law of conservation of momentum for rotating bodies as well. We formulate the conclusion:

3. Forces are always associated exclusively with material bodies, and a change in the course of time cannot alter the momentum of a system. In other words, the course of time does not transfer momentum.

The change in the active force acting on the top can be detected by the change in the deformation of the top during rotation. In those cases where the distinction between active and passive forces is beyond doubt, the sign of the universal course of time c_2 can be established by these experiments using formula (10). Indeed, it follows from this formula that a decrease in the active force occurs when the vector $j(u/c_2)$ coincides with the direction of the active force.

Since $c_2 > 0$, a decrease in the active force will occur when the rotation vector ju is directed along the active force. Let us assume now that we observed a decrease in the active force or forces during a certain rotation of the top. From these observations, we determine in which coordinate system the rotation vector coincides with the direction of the active force. In this coordinate system, the constant c_2 will have a positive value.

The next two Chapters contain a description of some effects of the course of time that can be observed on the surface of the Earth and other planets, as well as during laboratory experiments with gyroscopes. The main, qualitative result of these observations is that the decrease in the weight of the top occurs when it rotates clockwise, if viewed from the side toward which the gravity of the top is directed. By conventional methods of natural science, it is indisputably established that gravity is an active force. Therefore, these experiments clarify that the pseudovector of rotation ju is directed along the active force in a left-handed coordinate system. Thus, we obtain the sign of the course of time, which is one of the most fundamental characteristics of our World.

4. The experimentally determined sign of the course of time of our World is positive in a left-handed coordinate system. This means a decrease in the active force applied to a body when it rotates clockwise, if viewed from the side of the action of the active force.

If formula (4) is considered as a definition of Planck's constant, then the sign of this constant must also be positive in a left-handed coordinate system. In the example of Gauss discussed above, both isolated beings are always connected to each other by a single universal course of time. Obviously, by using Conclusion 4, they can easily agree upon their definitions of right and left. For this, it is sufficient for them to agree that rotation from left to right, when viewed from the side of any active force, is called the rotation during which a decrease in this force occurs. In exactly the same way, by observing the laboratory in a mirror, one can detect that in this case the sign of the course of time is positive in a right-handed coordinate system, and in this way establish the unreality of the observed laboratory.

Now, when the sign of c_2 is known, it is possible through mechanical experiments to distinguish an active force from a passive one, i.e., the cause from the effect. If, for example, a decrease in forces is observed during the rotation of a body, then the active force will be the one directed from where the rotation appears to occur clockwise. This circumstance satisfies the primary requirement we place on mechanics:

5. An active force can always be distinguished from a passive one, or a cause from an effect, by a mechanical experiment. Therefore, a device indicating the position of causes and effects is fundamentally possible.

In engineering, the search for causes requires the intuition of an engineer. Therefore, the existence of a fundamental possibility to find a cause in a mechanical way can be of great interest for technology.

During the relative rotation of a system of interacting bodies, additional internal forces arise in this system. These forces disturb the initial equilibrium of the system. Since the equilibrium state is a state of minimum energy, any disturbance of equilibrium means an increase in the energy of the system. Upon cessation of rotation, the system will each time return to the equilibrium state with additional (kinetic) energy. From this follows the conclusion:

6. The energy of a system of bodies in equilibrium can only increase with any change in the relative rotations of the bodies constituting the system. Thus, a motor using the course of time to obtain work is fundamentally possible. In other words, time possesses energy.

Let us now consider the case when the system is not in equilibrium and possesses kinetic energy. Then, with a change in relative rotations, there may appear forces acting against the velocity, which, like friction, can reduce the kinetic and, consequently, the total energy of the system. For example, the forces of the course of time can stop the vibration of a system if they are introduced in such a way that they act against the velocity of the vibrations.

7. The energy of a system of bodies not in equilibrium can be not only increased but also decreased by a change in the course of time. Therefore, the reverse process of the transition of the energy of the system into the course of time is possible.

Due to the exceptional importance of these consequences, let us examine the simplest concrete example of an engine operating on a change in the course of time. Suppose that a top with a vertically arranged axis rests on some rigid base and has the following design. A heavy ring of mass m lies on an elastic weightless spring, the elasticity coefficient of which is equal to k. The connection with the axis of rotation is carried out only at the bottom of this spring. During rotation in one direction or another, two additional forces must arise. One force, like the weight of the top, is applied to the center of gravity of the ring. The other force, paired with it according to Newton's third law, will be applied to the support, due to which the action of the top on the support does not depend on the state of rotation. These forces will stretch or compress the spring and impart to it an additional potential energy ΔE, which, according to formulas (10) and (6), can be represented in the form:

$$\Delta E = \frac{(\Delta F)^2}{2k} = \frac{(g-w)^2\, m^2}{2k}\left(\frac{u}{c_2}\right)^2 = \frac{(g-w)^2\, mT^2}{8\pi^2}\left(\frac{u}{c_2}\right)^2, \qquad (12)$$

where g is the acceleration due to gravity, w is the vertical acceleration of the ring and $T = 2\pi\sqrt{m/k}$ is the period of natural vibrations of the spring.

Let us assume that our top, with the help of some device without loss of energy, periodically changes its direction of rotation. For simplicity, let us assume that this period coincides with the period of natural vibrations of the spring. Then, from formula (12), it is easy to obtain the average amount of energy that our system will receive per unit time:

$$\frac{d\overline{E}}{dt} = \frac{m\,g^2 T}{8\pi^2}\left(\frac{\overline{u}}{c_2}\right)^2. \qquad (13)$$

Here $\overline{u}$ is the average value of the absolute linear velocity of rotation, and it is assumed that $w \ll g$. Let us assume the following data $m = 1$ kg, $T = 1$ s, $\overline{u} = 30$ m/s. Then we obtain $d\overline{E}/dt \cong 0.1$ erg/s.

The performance of our engine is very low.

Indeed, the energy of rotation alone of the system is about 10^8 erg. Therefore, only if friction is eliminated to such an extent that the system can vibrate by inertia for several years, then only in that case will the per-second loss of energy be of the order of the energy input. We see that the practical realization of a "time machine" with the help of tops is hardly possible. On laboratory scales, the role of time effects turns out to be utterly negligible. But in such immense bodies as stars and planets, time effects can be of decisive importance. The problem of the energy sources of celestial bodies can be completely solved in this way. Indeed, the immense loss of energy occurring on the surface of stars corresponds to a very small expenditure when referred to a unit mass of the star. Thus, for example, to maintain the thermal balance, each gram of matter inside the Sun must release only 1.9 erg/s. Our calculation of the power of the time engine presented above shows that on the scale of the Sun, processes are entirely possible in which a sufficient amount of energy will be extracted from the course of time. Most likely, these processes will be associated not with simple mechanics, but with electrodynamics. Magnetic field strength is a pseudovector, and therefore the pseudovector of the course of time can lead to new forces in electrodynamics as well, creating excess energy. One might think that it is not mechanics, but rather asymmetric electrodynamics that will allow for the practical realization of a time engine.

Until now, our reasoning has referred to the simplest case, where the axis of the top coincided with the line of action of the force. In this case, the pseudovectors of rotation were algebraically added to the pseudovectors of the course of time. In the general case, however, for any position of the axis of rotation, it is natural to consider that the pseudovectors of rotation and the course of time will add geometrically. Then formulas (9)–(11) for the transformation of forces will remain as before, provided that the terms included in their addition are treated geometrically. To determine the direction of the additional forces, it is convenient to use the following rule, which follows from Conclusion 4 and the formulas for the transformation of forces:

8. Additional active forces arising during the relative rotation of two interacting points are always directed along the axis of rotation toward the side from which the rotation appears to occur counterclockwise from the viewpoint of the coordinate system associated with the other point. Additional reactions are directed in the opposite directions.

In the general case, a change should be observed not only in the magnitude of the forces, but also in their directions, i.e., the aberration of forces. In this case, an additional pair of forces can arise in the system, which will alter the torque of this system. Thus, to the main properties of the course of time listed above (3 and 6), another property should be added:

9. The course of time can alter not only the energy, but also the torque of a mechanical system.

As was indicated in the first Chapter, the astronomical confirmation of this possibility for a mechanical system to obtain additional torque without the participation of other bodies can be found in the non-synchronicity of orbital and axial rotations observed in some close stellar pairs. In the next two Chapters, descriptions of mechanical experiments will be given, which directly demonstrate the possibility of altering the mechanical angular momentum of a system.

The additional term in the formula for the transformation of an active force during relative rotation (10) shows that a certain fraction of the effect becomes a cause in this cause-and-effect relationship. This implies the possibility of using a kinematic method to alter an existing causal chain of phenomena and to act upon the cause by means of the effect. In Newtonian mechanics, the additional term in formula (10) is absent. Indeed, this term must vanish, since conventional mechanics is obtained from causal mechanics by the limiting transition $c_2 \rightarrow \infty$. In conventional mechanics, the reversal of causal relationships becomes impossible. Therefore, conventional mechanics corresponds to a World with infinitely rigid causal connections. We cannot carry out the other limiting transition using the obtained formulas. The point is that the force transformation formulas (9) and (10) are only a linear approximation, in which only terms of the first order of smallness relative to u/c_2 are taken into account. However, we can conclude that for small values of c_2, the additional terms will play a major role, and mechanics must become completely unlike Newtonian mechanics. The limiting case $c_2 = 0$ signifies the complete absence of causal relationships and must lead to the formulas of atomic mechanics. Real mechanics, corresponding to a finite value, must be more close to conventional mechanics than to atomic mechanics. Thus, a system of real mechanics is easier to construct by studying ordinary macroscopic mechanical phenomena, rather than the phenomena of the atomic world. We have the right to expect that the corrections to Newtonian mechanics will include a number of features characteristic of atomic mechanics. Indeed, the subsequent Chapters describe experiments that indicate the appearance of discrete states in an ordinary mechanical system, which are so characteristic of atomic phenomena.

In conclusion of this Chapter, let us describe one more simple inference, which follows from the circumstance that during the free motion of a body, action is absent, and, consequently, additional forces will also be absent:

10. A free body, acted upon only by independent forces, must move according to the conventional laws of mechanics under any state of its rotation.

For example, during free fall, a rotating top must have the conventional acceleration due to gravity. Undoubtedly, in the first approximation, the motions of the planets around the Sun must also occur independently of the state of their rotations. We nevertheless believe that in celestial mechanics and stellar dynamics, some effects of causality may arise due to the inhomogeneity of gravitational fields, when not all forces acting on a body can be considered independent. The development of this important problem requires refinement of the concept of dependent forces. This question, like a number of other important questions — for instance, about the point of application of forces in reverse causal relationships — we shall leave without consideration for now. The point is that these questions should hardly be solved by continuing our deduction. It is significantly simpler and more reliable to find answers to them from direct experiments. The analysis carried out here shows clearly enough what these experiments should consist in and predicts a number of fundamental phenomena that must first and foremost be verified by experiment. The possibility of the existence of even the predicted phenomena will seem like a fantasy until these phenomena are proven directly. Therefore, it is necessary to proceed to the direct presentation of the experimental data.

Chapter IV. Phenomena of causal mechanics caused by the rotation of the Earth and other planets

The previous Chapter considered the basic problem of the interaction of a heavy top with a fixed support. The causality effects of this problem should manifest themselves in various deformations of the top when it rotates in different directions. However, under laboratory conditions, it is very difficult to set up an experiment in which these effects would be sufficiently perceptible. The point is that at small body sizes and high rotation velocities, the deformation of the body will be determined not by weight, but by centrifugal forces, relative to which the causality forces of interest to us will turn out to be very small. Only in bodies of planetary dimensions can there be high rotation velocities at small centrifugal forces. In rotating celestial bodies, there is an interaction between rapidly rotating equatorial masses and slowly rotating masses located near the axis. The majority of the planets in the Solar System rotate counterclockwise when viewed from their north pole. According to Conclusion 8 of the previous Chapter, additional active forces directed to the north must act on the equatorial masses. On the masses located near the axis of rotation, the same forces must act in the southward direction. Obviously, on the surface of the Earth, in both hemispheres, there will exist a parallel at which the causality forces are equal to zero. As a result of the action of additional forces, the Northern Hemisphere of the planet must become more compressed, and the Southern Hemisphere more convex. The figure of the planet will become asymmetric with respect to the equatorial plane and will be a cardioid in the meridional section. The resulting figure can be described by introducing an additional odd term into the ellipsoid equation:

$$r = a\left(1 - \varepsilon \cos^2 p - \eta\, f(\cos p)\right), \tag{14}$$

where r is the radius vector of a point on the surface of the planet, drawn from the point of intersection of the axis of rotation with the equatorial plane, i.e., the plane of the maximum section, a is the radius of the equatorial section, p is the polar distance measured from the North Pole of the planet, and ε is the flattening. The function $f(\cos p)$ must contain only odd powers of $\cos p$. For a mall η, the term with the first power will be equivalent to a shift of the origin of coordinates. Therefore, the function $f(\cos p)$ can contain powers of $\cos p$ only starting from the cube and higher. Let us note that to obtain a cardioid rather than an oval, the function $f(\cos p)$ must consist of at least two terms with different powers of $\cos p$. We normalize $f(\cos p)$ such that at the North Pole ($p = 0°$), $f = +1$. Then η can be called the coefficient of asymmetry:

$$\eta = \frac{b_S - b_N}{2a}\,. \tag{15}$$

Here b_S and b_N are the southern and northern polar semi-axes, respectively. With a decrease in the flattening of the Southern Hemisphere compared to the northern one, $b_S > b_N$

and $\eta > 0$. Limiting ourselves to the cube and the fifth power of $\cos p$, we will have the following expression:

$$f(\cos p) = \frac{\cos^3 p - k\cos^5 p}{1-k}\,. \tag{16}$$

Since the angle between the normal and the radius vector is equal to r'_p/r, the angle between the normal to the cardioid and the normal to the ellipsoid must have the value:

$$-\frac{\eta}{1-k}\,(3\cos^2 p - 5\cos^4 p)\,\sin p\,.$$

The minus sign corresponds to a northward deflection of the normal inside the cardioid. This expression will vanish approximately at that parallel p_0 where the asymmetrical forces disappear. From this:

$$k = \frac{3}{5\cos^2 p_0}\,. \tag{17}$$

From formula (10) it follows that:

$$\eta = \frac{\beta u}{c_2}\,, \tag{18}$$

where u is the equatorial rotation velocity of the planet and β is a certain dimensionless coefficient depending on the structure of the planet. The forces that create the asymmetry are distributed in some manner throughout the entire mass of the planet. We do not possess sufficient knowledge of the matter to state exactly how this distribution occurs. It is only obvious that the coefficient β must be at least an order of magnitude less than unity.

Of the planets in the Solar System, Jupiter and Saturn have the largest equatorial velocity u. For Jupiter, $u = 11$ km/s and the expected value of η should be about $+3\times10^{-3}$. In angular measure, the asymmetry $2a\eta$ should be of the order of 0″.1. Such a value can be fully detected by differential measurements of photographic plates obtained with large instruments. Numerous plates of Jupiter and Saturn, obtained at various observatories, were measured by the author and D. O. Mokhnatch. Without dwelling on the description of the methodology of these measurements [5], we present the final results in the form of a table, which includes the probable value of the Earth's asymmetry:

Table I

Planet	u, km/s	u/c_2	η	β
Saturn	10	1.4×10^{-2}	$+7\times10^{-3}\pm3\times10^{-3}$	0.5
Jupiter	11	1.6×10^{-2}	$+3\times10^{-3}\pm0.6\times10^{-3}$	0.2
Earth	0.4	0.6×10^{-3}	$\approx+3\times10^{-5}$	0.05

The third column of this Table is calculated according to expression (4) with $a = 2$. The last column gives the values of β calculated by formula (18). These values agree reasonably well with the tentative estimate made earlier. The larger values of β obtained for Saturn and Jupiter can be explained by the significant inhomogeneity of these planets in comparison with the Earth. Indeed, let us imagine the mutual attraction of only two masses: stationary m_0 and rotating m_u. Then the action of these masses on each other, proportional to $m_0 m_u$, with a constant total mass $m_0 + m_u$, will have a maximum value when $m_0 = m_u$. Schematizing the planet in this way, we must consider $m_0 < m_u$, which leads to small values of β. With an increase in concentration, these masses will equalize, their action will become greater, and this will lead to an increase in the coefficient β.

The data in Table I show that the asymmetry of planets relative to the equatorial plane indeed exists and that the Southern Hemisphere of the planets is more elongated than the northern one $\eta > 0$. When reflecting the planets in a mirror, we must see the opposite picture, namely, the elongation of the hemisphere from which the rotation appears to occur counter-clockwise. Thus, as early as 1949, these astronomical observations demonstrated the physical non-equivalence of the World and its mirror image, which much later was discovered in the microcosm through the refutation of the law of conservation of parity in weak interactions.

The value of η for the Earth given in Table I is a very rough estimate that can be made on the basis of the latitudinal asymmetry coefficient in the gravity distribution. A detailed study of summary data on the Earth's gravitational field, carried out by I. D. Zhongolovich, confirmed the long-known circumstance of a greater value of gravity in the Northern Hemisphere. According to Zhongolovich: $\Delta g = g_N - g_S = +30$ mGal and, consequently, $\Delta g/g = 3\times10^{-5}$. For a homogeneous planet, one can conclude from this that the North Pole is located closer to the center of gravity of the planet than the South Pole. The Southern Hemisphere of the Earth, as with other planets, turns out to be more elongated, and it can be approximately considered that $\eta \approx \Delta g/g$. To avoid misunderstandings, it should be noted that surveyors, interpreting data on gravity asymmetry using Clairaut's or Stokes' theorems, arrive at the opposite conclusion — about a greater elongation of the Northern Hemisphere. The essence of this discrepancy lies in the fact that the theory of the Earth's figure considers the Earth's surface as a level surface of only two potentials — gravity and centrifugal forces. Under such consideration, the possibility of asymmetry of a homogeneous body is excluded, and the found value of Δg can only be explained by an excess of dense matter in the Northern Hemisphere, essentially a contradictory assumption of a non-equilibrium state of the Earth. In this case, the level surface of the same gravity value will recede further, and an elongation of the hemisphere with a greater gravity value will be obtained. As can be seen, this interpretation is unlikely, but it can only be definitively eliminated by direct geodetic degree measurements of the Earth's figure.

It is interesting to note that for $\eta > 0$, the meridional section of the planet, according to equation (14), must be a

Table II

Observer	Year	Location	Fall height, meter	Eastward deflection, mm		Southward deflection, mm	
				observ.	theor.	observ.	theor.
Hooke	1680	London	8.2	+	+0.3	+	+0.2
Guiglielmini	1791	Bologna	78.3	+18.9	+9.2	+11.9	+2
Benzenberg	1802	Hamburg	76.3	+9.0	+8.91	+3.4	+2
— " —	1804	Schlebusch	84.4	+	+10.04	0	+3
Reich	1831	Freiburg	158.5	+28.4	+27.50	+4.4	+5
Rundell	1848	Cornwell	400	+	+110	+250?	+12
Hall	1902	Cambridge, Mass	23	+1.49	+1.79	+0.05	+0.7
Flammarion	1903	Paris	68	+7	+8	−1.0	+2

cardioid, indented at the north and pointed toward the south. The presence of the Antarctic continent and the Arctic Ocean basin, as well as the preferential location of continents in the Northern Hemisphere, give the Earth the appearance of exactly such a cardioid. Probably, this circumstance is not accidental, since the action of weak forces that break symmetry could create a preferential direction for processes inside the Earth.

It is highly important to prove now, by direct experiments, the existence of the forces causing the Earth's asymmetry. The simplest experiment follows from Conclusion 10 of the previous Chapter, according to which asymmetric forces do not act at all on a freely falling body. Observations show that a plumb line is perpendicular to the level surface. From this it follows that the causality forces arising from the interaction of the rotating and non-rotating masses of the Earth, propagating throughout the entire connected mass of the Earth, are transmitted through the suspension point and deflect the plumb line toward the north in moderate latitudes. When the connection is broken and the body begins to fall freely, the forces deflecting it to the north cease to act upon it, and, in addition to the conventional eastward deflection, it will shift further to the south of the vertical by the value:

$$\Delta l_S = \eta l = 3 \times 10^{-5}\, l\,, \tag{19}$$

where l is the height of the body's fall. The southward deflection turns out to be proportional to l, whereas the eastward deflection is proportional to $l^{3/2}$; therefore, at small heights, practically only the southward deflection should remain. The numerical estimate (19) of the southward deflection corresponds to the moderate latitudes of both hemispheres. At the critical parallels ($p = p_0$), there will be no deflection of the line of fall from the plumb line. Near the poles, however, a very small northward deflection should be observed.

The first experiments, performed by Hooke in January 1680 at Newton's initiative to verify the eastward deflection of falling bodies, led Hooke to the conviction that a falling body deflects not only to the east, but also to the south. A hundred years later, Guglielmini in Bologna engaged extensively with these experiments and arrived at the same conclusion. Subsequently, these experiments by Guglielmini were called into question and, in the first half of the nineteenth century, were repeated by a number of researchers. John Herschel considered establishing the reality of the southward deflection to be a most important problem of mechanics. However, despite all the efforts of the researchers, it was not possible to obtain reliable results. It is well known that these experiments are always fraught with large errors that prevent one from reliably obtaining even the significantly larger eastward deflection. In 1902, Hall in America attempted to definitively resolve the question of the existence of the southward deflection through numerous and meticulous experiments, but, as he himself writes, he failed to settle this question. Table II presents the results of all performed experiments on the fall of bodies.

In this Table, the theoretical eastward deflections are calculated by the formula $\Delta l_{East} = \frac{1}{3}\, g\omega t^3 \cos\varphi$ (t is time of fall, seconds), and the southward deflections according to expression (19). Judging by the setup of the experiments and their results, the best data were obtained by the engineer Reich in a Freiburg mine. To show to what extent even these best determinations are unreliable, let us present the following table characterizing Reich's experiments [12]: see Table III.

The data in Tables II and III cannot serve as rigorous experimental proof of the existence of the southward deflection. However, they show that the existence of this deflection according to formula (19) is highly probable. It is interesting that Benzenberg, who did not obtain a noticeable southward deflection in repeated experiments in 1804, wrote: "Sonderbar bleibt doch diese Tendenz der Fehler nach Süden".*

At present, there is a misconception that experiments on the fall of bodies on an Atwood machine, very meticulously conducted by Hagen [13] in the Vatican, completely disproved the existence of the southward deflection. In these experi-

*Which means: "Yet, oddly enough, this trend of southward deflection persists." — Editor's comment.

Table III

Number of experiments	Eastward deflection, mm	Probable error, mm	Southward deflection, mm	Probable error, mm
22	+27.13	± 8.06	+6.69	± 9.92
12	+27.32	13.97	+23.05	16.57
12	+16.34	10.02	−1.36	15.72
18	+46.34	8.02	+12.49	15.24
21	+29.03	5.92	−7.88	6.06
21	+10.70	11.20	−16.02	14.13

ments, the height of the fall was 23 m, and the acceleration of the fall was reduced to 1/25. It follows from theory that due to the tension of the thread, the magnitude of the eastward deflection must decrease by a factor of two compared to free fall. Hagen obtained a value of $\Delta l_{East} = +0.899 \pm 0.027$ mm, which agrees with the theoretical one to an accuracy of 1%. The southward deflection, however, turned out to be actually zero in his experiments: $\Delta l_S = +0.010 \pm 0.027$ mm. However, this disproof is only apparent. Indeed, the eastward deflection occurs according to a completely different law than the southward one. On an Atwood machine, the eastward deflection decreases only by a factor of two; the southward deflection, however, due to the fact that the body is decoupled only to 1/25, must decrease by a factor of 25 according to formula (6) in comparison with (19) and amount to $\Delta l_S = +0.03$, a value that absolutely does not contradict Hagen's results.

The high accuracy of Hagen's results is mainly explained by the low velocities of the falls. In experiments on southward deflection, reducing the velocity is possible only by decreasing the height of the body's fall. Therefore, to verify the existence of the deflection to the south, an experiment was carried out by us in Pulkovo involving a body falling from a height of only 17 mm into water. The falling body was specially manufactured with meticulously executed axial symmetry. It was a thin-walled brass cylinder with a diameter and a height of about 4 cm, merging at the bottom into a solid hemisphere of the same diameter. From above, the body was closed with a light (aluminum) lid, with a removable cylindrical head in the center, which had a small hole (diameter of the order of 0.1 mm). A thin hair passed through this hole, from which the body was suspended. The body was placed in the center of a cylindrical glass vessel containing water, with a diameter of about 40 cm, closed with a transparent lid. The suspension hair passed through a small central hole in this lid, then passed along the axis of a high-resistance coil, which served to burn through the hair, and was secured with a lifting clamp. The coil and clamp were mounted on the lid of the vessel. In a free state, the body had stable buoyancy, and the waterline passed 2 cm below its upper edge. When the body was lifted to a height of 17 mm, its weight decreased by exactly a factor of 2. By turning on the current, it was possible to melt the hair inside the coil and achieve the fall of the body without horizontal jolts. After falling, the body oscillated strictly vertically with rapid damping. Let us denote by l the height of the body's lift above the waterline. Disregarding damping:

$$\frac{d^2 l}{dt^2} = -a\,l\,, \qquad l = l_0 \cos\sqrt{a}\,t\,,$$

and, consequently, for the period of oscillations T we obtain

$$T = \frac{2\pi}{\sqrt{a}}\,.$$

Substituting the initial data into these expressions

$$\frac{1}{2}\,g = \left(\frac{d^2 l}{dt^2}\right)_0, \qquad l_0 = 1.7\,,$$

we find: $a = 3\times10^2$; $T = 0.4$ s.

Observations of the horizontal displacements of the body after falling were made along perpendicular directions using two periscopes inserted into the lid of the vessel. The measuring tubes were located in another room at a considerable distance from the entire setup. A small electric lamp was installed above the lid of the vessel, which produced a vertical reflection on the cylindrical head of the body. Observation of the reflection eliminated errors associated with a possible rotation of the body. The damping of the horizontal velocity of a body floating in water occurs very slowly. Therefore, a small initial velocity can lead to a very noticeable horizontal displacement. Observations showed that the horizontal velocity of our body decreased according to the law $v = v_0\,l^{-t/t_0}$ at $t_0 = 120$ s. Thus, the total horizontal displacement was equal to the distance that the body would travel under uniform motion in 2 minutes.

Let us now attempt to estimate the magnitude of the expected southward displacement. The southward acceleration according to (19) is 3×10^{-5} of the actual vertical acceleration of the body. Therefore, during a half-period when the acceleration is directed downward, the body must acquire a southward velocity:

$$v_S = 3\times10^{-5}\int_0^{T/2}\frac{d^2 l}{dt^2}\,dt = \\ = 3\times10^{-5}\times 2\sqrt{a}\,l_0 = 2\times10^{-3}.$$

During the other half of the period, the action of gravity, according to the second formula (6), remains unchanged, and the horizontal velocity of the body cannot alter. Thus, over n periods, a horizontal displacement of the body must result: $l_S = v_S t_0 n = 2.4$ mm. If all the oscillations of the body are equivalent to two or three undamped oscillations, then the displacement of the body to the south should amount to 5–7 mm.

The practical realization of this experiment was hindered by convection currents in the water. By placing the vessel containing the body inside another vessel filled with water, which in turn was enclosed by a cylindrical shield made of polished tinplate, it was possible to reduce the velocity of the convection currents to 0.1–0.2 mm/min. Another difficulty lay in achieving a symmetrical clamping of the hair without a preferential plane of tension. The possibility of such a preferential plane was reduced to a significant degree. Nevertheless, to eliminate these errors, the experiments were performed at various azimuths by rotating the entire setup. After the body was suspended, the experiment was performed several hours later. Fig. 1 depicts the results of these measurements of the total displacement of the body in water after falling. The coordinate axes X and Y were chosen randomly, in accordance only with the orientation of the room in which the experiments were conducted. The center of the resulting cloud of points is indeed located to the south at a distance of 8–9 mm from the suspension point, which agrees well with the predicted result. The eastward deflection in this experiment should amount to only fractions of a millimeter. Therefore, the resulting small eastward displacement must be the consequence of some systematic error that was not completely eliminated.

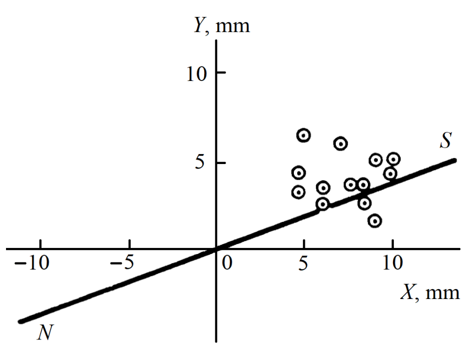

Fig. 1: Deflection from the plumb line of the final position of a body after falling into water from a height of 1.7 cm.

On the surface of the Earth, the transformation of ordinary gravity $A(p)$ into the observed gravity $A'(p)$ has the form:

$$A'(p) = A(p) + j\gamma(p)\,|A(p)|\,, \tag{20}$$

where $\gamma(p)$ represents a coefficient of the order of 10^{-5}, which depends on the polar distance p and is positive in the moderate latitudes of both hemispheres. According to Conclusion 8 of Chapter III, this transformation corresponds to the following transformation of reactions:

$$R'(p) = R(p) - j\gamma(p)\,|R|\,. \tag{21}$$

Formulas (20) and (21) are the result of the transformation of the course of time. Therefore, it can be assumed that other forces in systems bound to the Earth's surface will also be modified in accordance with these formulas: elastic forces — analogously to reactions according to formula (21), while inertial forces — analogously to gravity according to formula (20). The validity of this assumption is easiest to verify by the action on a system of periodic forces. Indeed, the time averages of these forces $\overline{A}$ and $\overline{R}$ are equal to zero, whereas

$$A'(p) = j\gamma(p)\,|\overline{A}|\,, \qquad R'(p) = j\gamma(p)\,|\overline{R}|\,. \tag{22}$$

For example, during oscillations of a system in a horizontal plane, a northward shift of the oscillating body should result. To obtain noticeable shifts, the forces stopping the body must increase with distance very gradually. At the same time, the periodically varying forces should be as large as possible. These conditions will be satisfied by a long pendulum whose body is imparted significant horizontal accelerations by the oscillation of the suspension thread. In the initial version of the experiment, a symmetrical body of a pendulum weighing about 30 g was suspended by means of a thread with a thickness of the order of 0.1 mm and a length of 180 cm (period 3 s) to an iron plate, which could be pulled vertically by electromagnets located above it. By changing the current frequency, it was possible to create any vertical tremors of the suspension. During tremors, the tension of the thread changes, and by selecting frequencies, it was possible to achieve the phenomenon of parametric resonance, when the pendulum thread turned into an oscillating string with a fixed and almost fixed end. The oscillations of parametric resonance were not polarized, and the thread had the appearance of a completely symmetrical spindle. Resonance was carried out at various frequencies, for example, at frequencies around 90 Hz, the distance between nodes turned out to be of the order of 60 cm with a full amplitude at the antinode of about 7 mm. Thus, the horizontal forces applied to the pendulum body were obtained of the order of several percent of the weight. It turned out that the pendulum can be swung or stopped in the meridian plane by turning on the current for a short time to cause parametric resonance when the pendulum passes near the equilibrium position. The same effect was obtained with constant tremor of the suspension by transitions from a non-resonant frequency to resonance. For 50 successive turn-ons of the current, when the pendulum moved to the north, a full swinging of 1 mm resulted. Stopping with this same initial amplitude was obtained for 15–20 turn-ons of the current during the movement of the pendulum to the south. From this, it can be concluded that in the presence of horizontal components of the thread tension, some additional force directed to the north acts on the pendulum. It turned out that the action of this force can be observed directly. Indeed, during prolonged turn-ons of the current, i.e., with constant parametric excitation, the average position of the pendulum shifted to the north by a value of about 0.04 mm from its position at rest or in the absence of resonance. Thus, the magnitude of this additional force acting to the north was found to be equal to 2×10^{-5} g.

This experiment should yield the value $\gamma_N(p)$ of the horizontal projection of the vector $j\gamma(p)$ according to formula (22). A correct result in terms of the order of magnitude is obtained if the full value of gravity $|\overline{A}|$ is taken for $A(p)$ in the formula. Thus, the horizontal forces acting on the body during parametric resonance only excite a transition to another equilibrium state, in which not the gravity force $A'(p)$ acts on the pendulum, but a force $A''(p)$ with a doubled coefficient $\gamma(p)$. The correctness of this conclusion was verified on pendulums with lengths of 3.30 m and 10.60 m. Using a narrow slit, it was also possible to obtain oscillations polarized in a specific plane. It turned out that the transition to the excited state $A''(p)$ is realized only by means of horizontal forces acting in the meridian plane. By rotating the polarization plane, at a sufficiently large amplitude of oscillations, it was possible to find a critical angle at which the effect either appeared or disappeared. A further increase in the projection of the oscillations onto the meridian plane did not alter the achieved state $A''(p)$. The transition to the state $A''(p)$ always occurred jump-wise, as soon as the projection of the horizontal accelerations onto the meridian plane reached several percent of g. The appearance of the effect was completely independent of the resonance frequency, i.e., of the number of nodes on the pendulum thread. The northward displacement of the body of a pendulum with a length of 10.60 m was 0.21 mm in Pulkovo. As seen from Fig. 2, the linear effect

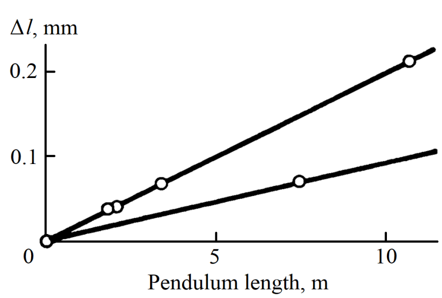

Fig. 2: Linear displacement of a pendulum during vibrations as a function of the length of the pendulum. The upper straight line corresponds to observations in Pulkovo ($\varphi = 59°46'$), the lower one to observations in the Botanical Garden of the town of Kirovsk ($\varphi = 67°39'$).

is strictly proportional to the length of the pendulum. With an increase in the latitude of the observation site, a significant decrease in $\gamma_N(p)$ was to be expected: firstly, due to the decrease in the horizontal projection, and secondly, due to a sharp decrease in the vector $j\gamma(p)$, the magnitude of which must pass through zero in high latitudes. Indeed, experiments in the town of Kirovsk (Polar-Alpine Botanical Garden of the Academy of Sciences, $\varphi = 67°39'$ showed a decrease in by more than a factor of two compared to Pulkovo, $\varphi = 59°46'$ (see Fig. 2). When observing this small effect in Kirovsk, it turned out that at very large oscillations of the pendulum thread, it can transition into the next excited state $A'''(p)$, with a tripled coefficient $\gamma(p)$.

The forces under study are directed along the axis of rotation of the Earth. Therefore, in the moderate latitudes of the Northern Hemisphere, vertical projections directed upward should be observed, which one can attempt to obtain during vibrations of a system with a vertical degree of freedom. The simplest system of this kind is a beam balance. Let us assume that on one end of the balance beam a load is suspended from a rigid suspension, which can transmit the vibrations of the beam to the load. The other, balancing load is suspended by means of rubber shock absorbers that damp the oscillations. Then, during vibration of the balance, a decrease in the weight of the vibrating load can be observed. In the performed experiments, the support of the balance beam was enclosed by a special bracket, which was connected by a flexible cable to an electromagnetic relay located above the balance. Usually, balances have guides for the vertical movement of the beam support during the locking of the balance. Thanks to these guides, vertical oscillations of the beam were obtained without lateral rocking. By supplying an alternating current from an audio generator to the relay, it was possible to cause vibration of any frequency without disrupting the quality of the balance readings. Still, these experiments should be performed on a balance of low sensitivity (of the second class), in which the edges of the knife-edges are in contact with planes having the shape of caps.

Experiments with the balance showed that the reduction in weight of the rigidly suspended load, just like the displacement in the pendulum experiments, occurs jump-wise, starting from a certain vibration amplitude. One has to select the optimal amplitude at which the effect is obtained but the balance is not put out of order. During multiple weighings, it was possible to measure the reduction in the weight of the load with an accuracy of up to several tenths of a milligram. Fig. 3 depicts the results of these experiments, performed in Pulkovo and in the Botanical Garden of the town of Kirovsk. As follows from our formulas, the reduction in the weight of the load turned out to be proportional to its weight. The slope of these graphs gives $\gamma_Z(p)$, i.e., the vertical projection of the vector $j\gamma(p)$. Using these values and the values of the horizontal components from Fig. 2, it is possible to determine φ' — the angle of inclination of the vector $j\gamma(p)$ to the horizon:

$$\tan\varphi' = \frac{\gamma_Z}{\gamma_N}\,. \tag{23}$$

Table IV

Location	Latitude	$\gamma_Z(p)\times 10^5$	$\gamma_N(p)\times 10^5$	$\gamma(p)\times 10^5$	φ'
Pulkovo	59°46′	3.40	2.00	3.96	59°32′
Kirovsk	67°39′	2.32	0.93	2.50	67°58′

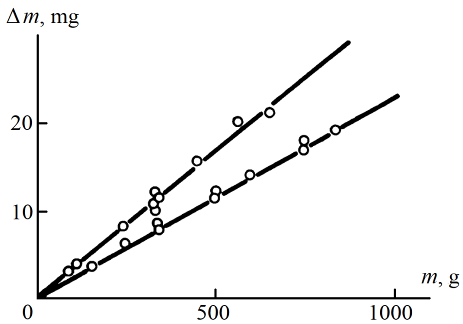

Fig. 3: Reduction in the weight of a load during vibrations as a function of its weight. The upper straight line corresponds to observations in Pulkovo ($\varphi = 59°46'$), the lower one to observations in the Botanical Garden of the town of Kirovsk ($\varphi = 67°39'$).

Table IV presents the results of all performed measurements.

From this Table, it can be seen how well the angle φ' coincides with the latitude of the observation site. This result convincingly shows that the forces observed in experiments with vibrations are indeed equal to the additional asymmetric gravity forces acting on the surface of the Earth. Thus, a very simple method was found for the direct measurement of the forces causing the Earth's asymmetry. By extrapolating the data of Table IV, one can estimate the critical latitude φ_0 at which the asymmetric forces vanish: $\varphi_0 = 73°$ ($p_0 = 17°$). Then, from formula (17), it follows that: $k = 0.66 = 2/3$ m; according to equations (16) and (14), the figure of the Earth must be described by the formula

$$r = a + \left[1 - \varepsilon\cos^2 p - \eta\,(3\cos^3 p - 2\cos^5 p)\right]. \quad (24)$$

It is highly significant that the critical parallel we obtained corresponds in the Northern Hemisphere to the boundary of the continents and the beginning of the Arctic Ocean basin, and in the Southern Hemisphere, conversely, to the parallels of the uplift of the Antarctic continent.

In the region from the critical latitude to the pole, the asymmetric forces change sign, so an increase in the weight of the vibrating load should be observed on the balance. This increase in weight will reach its greatest value at the pole, of the order of the absolute value of the vector $j\gamma(p)$ of moderate latitudes. Thus, in the polar regions, one should expect a change in the weight increase of a 1 kg load by about 0.2–0.3 mg per 5° of latitude. It is highly probable that in this way a practically useful determination of latitudes in polar countries can be carried out. To study the asymmetric forces, it is desirable to obtain as many measurements of $\gamma(p)$ as possible over the entire surface of the Earth. In addition to the regular change in the forces $\gamma(p)$ with latitude, some longitudinal changes can also be expected, which will allow for establishing the existence of deep inhomogeneities in the Earth.

The deflection of the pendulum and the balance beam during vibrations clearly demonstrates the validity of Conclusion 9 of the previous Chapter regarding the possibility of altering the torque of a system by the forces of the course of time. One of the forces constituting the pair is applied to the vibrating load, while the other force, as experience shows, is applied to the source of vibrations.

In other words, the additional forces are internal with respect to the vibrator-load system. Indeed, by suspending the entire vibrator-load system from the balance in any manner, one can verify that in this case, no change in the balance readings occurs under various characteristics of vibrations.

At present, we will not seek a theoretical explanation for the observed effects. The point is that the experiments with gyroscopes, which will be presented in the next Chapter, show analogous effects with new features. Therefore, it is advisable to conduct the theoretical analysis after describing all the experiments, taking into account the totality of the results.

Regardless of the theoretical explanation, the experiments with the vibrations of loads show that under certain circumstances, asymmetric forces act on moving masses bound to the Earth, which are two or more times greater than the forces acting on the stationary masses of the Earth. Therefore, for masses in motion, the Earth's surface will not be a level surface, and a preferential movement of these masses toward the north should be observed in the moderate latitudes of both hemispheres. In the planet's atmosphere, one should expect the existence of a special circulation — the movement of tropospheric air masses to the north with a countercurrent to the south in the upper layers. Such a circulation will lead to a difference in the climates of both hemispheres of the planets, with the Northern Hemisphere becoming warmer than the Southern Hemisphere.

The indicated difference in the climates of both hemispheres of the planets does indeed exist. On the Earth, the average annual temperature of the Southern Hemisphere is 3° lower than the temperature of the Northern Hemisphere. As a result, the thermal equator turns out to be shifted by 10° to the north relative to the geographic one. Such a large difference in climates can hardly be explained by the eccentricity of the Earth's orbit. For Mars, as for the Earth, the Southern

Hemisphere is colder than the northern one. This is evidenced by the significantly greater development of the southern polar cap of Mars compared to the northern one. For Mars, this effect can to a significant degree result from the large eccentricity of Mars' orbit: winter in the Southern Hemisphere occurs at aphelion and must be significantly colder and longer than in the Northern Hemisphere. However, it is highly significant that for Venus as well, with a circular orbit, an intensification of bright spots near the South Pole compared to the North Pole is observed. It should be noted that at present, there are no exact data on the direction of rotation of Venus. Most likely, Venus rotates in the conventional direction, like other planets. An indirect circumstance can serve as confirmation of this. From the author's observations of the glow of the night sky of Venus, it can be concluded that this glow is somewhat greater during morning elongations than during evening ones. It is natural to consider that the glow should be stronger on the evening side of Venus, which will be observed during morning elongations in the case of direct rotation. Apparently, for the Sun too, there is such an asymmetry in the temperatures of the hemispheres. Spectrophotometric measurements of the solar surface temperature performed by Minnaert [11] showed that the South Pole of the Sun is 4° colder than the North Pole. The climatic difference between the hemispheres of the Sun is further emphasized by the fact that spots appear somewhat more frequently in the Southern Hemisphere than in the northern one. For planets, atmospheric circulation to the north transfers more heat to the Northern Hemisphere, mainly due to the movement of air masses heated in the tropics. On the Sun, the same effect will result from a possible northward shift of currents that carry more heat into regions of convective instability. The geometric asymmetry of the figure of the Sun has never been measured. At a linear velocity of the Sun's rotation at the equator of $u = 2$ km/s, one should expect an asymmetry in angular measure of about $1''$. Therefore, despite the technical difficulties, such measurements could yield a definite result.

Simultaneously with the forces shifting air masses to the north, there must exist oppositely directed forces applied to the surface of the Earth. These forces can cause southward displacements of the surface waters of the oceans. Due to the complexity and variability of currents in the upper layers of water, the predominance of movements to the south can hardly be noticed. However, the inevitable northward movement of the deep countercurrent can be detected by the penetration of southern polar waters to the north. Such a movement of deep waters apparently does exist in the Atlantic and Pacific oceans.

The material presented in this Chapter shows that many and diverse phenomena on the Earth are caused by the asymmetric forces of the course of time. Therefore, the experimental and theoretical development of causal mechanics should be of great interest for the sciences that study the Earth.

Chapter V. Laboratory observation of the phenomena of causal mechanics

The third Chapter mentioned experiments from which it can be concluded that the law of conservation of momentum is satisfied in causal mechanics as well. These experiments are fundamental, so they should be described in detail, despite the fact that no new effects confirming causal mechanics are detected in them.

The first fundamental experiment: weighing a top on a beam balance. The first weighings were performed by us in the Laboratory of Mass Measures of the USSR Institute of Metrology in 1951. Tops of various types were weighed: 1) with a lead rotor with a diameter $D = 4.6$ cm and a weight Q from 70 to 90 g, 2) with a brass rotor: $D = 4.6$ cm, $Q = 72$ g; $D = 7.2$ cm, $Q = 180$ g; $D = 4.6$ cm, $Q = 284$ g. The tops were set into rotation by hand using a thread wound around the axis. For light tops, rotation velocities of about 200–300 rps were obtained, and about 100–150 rps for heavy ones. Inertial rotation continued from 15 to 40 min, depending on the manufacturing quality of the top. The top set into rotation was placed in a light, hermetically sealed box. In this way, the influence of air currents on the weighing was completely eliminated. The weighing accuracy was successfully brought to 0.1–0.2 mg. These experiments showed that the force acting on the balance at velocities of 30–40 m/s does not change during rotation to an accuracy of one millionth.

The main disadvantage of weighing bodies that rotate by inertia lies in the inevitable twisting of the suspension and the balance beam. Indeed, due to the law of conservation of angular momentum, a decelerating top must transfer its momentum to the Earth through the balance support. To completely eliminate the twisting of the balance, it is necessary to keep the velocity of the top constant. Therefore, in subsequent experiments, a gyroscope taken from an aviation gyrocompass was weighed ($Q = 250$ g, $D = 4$ cm), the velocity of which was maintained by a three-phase alternating current with a frequency of 500–600 Hz. The rotation of the gyroscope rotor occurred at this same frequency. Despite the significant current strength (about 0.5 A), it proved possible to supply the current to the gyroscope suspended from the balance by means of three very thin wires, pre-annealed to reduce their elasticity. The loss of balance sensitivity due to these wires turned out to be negligible. The scale interval of the balance without the wires was 8 mg, and with the wires, it was 10 mg. Thus, at linear rotation velocities of about 70 m/s, it was possible to perform the weighing with an accuracy of up to 1 mg. No changes in the balance readings were detected in these experiments either.

The second fundamental experiment: weighing a moving top. In these experiments, the top was placed, as before, in a light, closed, hermetically sealed box. The box was suspended from an iron plate, which was attracted by electromagnets secured to a certain massive body. This entire system was suspended from the balance by means of an elastic, spring suspension. Current was supplied to the electromagnets in the manner described in the previous experiment. The current interruption system was installed separately from the balance. When the circuit was broken, the top fell under the action of gravity to a limiter secured to the electromagnets. The amplitude of these drops and subsequent lifts could reach 2 mm. Weighing was performed at different directions of the top's rotation, at different amplitudes, and at oscillation frequencies from several units to hundreds of hertz. In addition, experiments were performed at different values of the stationary mass included in the suspended system. For a rotating top, just as for a stationary one, the balance readings during the drops and lifts of the top turned out to be invariable. It can be considered that these experiments quite rigorously substantiate our theoretical conclusion regarding the conservation of momentum in causal mechanics.

When performing the described experiments, it turned out that in the case of balance vibration, effects are sometimes observed that are undoubtedly associated with the role of the direction of rotation in mechanics. A top suspended from a rigid suspension could transmit its vibrations to the balance beam.

With a certain adjustment of the top in its bearings, i.e., with a certain character of the balance beam's vibrations, a decrease in the balance readings (the action of the top on the balance) was observed only during the rotation of the top counterclockwise, if viewed in the direction of the gravity force. During rotation clockwise under the same conditions, almost no changes in the balance readings were observed. The conditions under which these effects appeared could not be reproduced at will. The regime necessary for this was established by accidental circumstances. This oscillation regime was accompanied by a characteristic sound. Under these conditions, the experiments could be repeated many times and yielded identical results. Then, negligible circumstances disrupted the required regime, and the balance, in accordance with the first fundamental experiment, ceased to change its readings. The experiments were performed with tops in thrust bearings rotating by inertia. These tops and their weighing are described at the beginning of the current Chapter. During rotation of the top counterclockwise with $D = 4.6$ cm, $Q = 90$ g, and $u = 25$ m/s, a reduction in weight $\Delta Q = -8$ mg was obtained. During clockwise rotation, it always turned out that $\Delta Q = 0$. In a horizontal position of the axis at any azimuth, a reduction of an intermediate value was observed: $\Delta Q = -4$ mg. This seemingly strange result at first glance is explained by the combination of the top's rotation effect and the Earth's rotation effect, due to which the weight of any vibrating body decreases. Indeed, the total weight of the top with its frame was 120 g, and from Table IV it follows that for Pulkovo, the reduction of such a load due to the Earth's rotation should be exactly -4 mg. Thus, the effect of the rotor's rotation itself turns out to be perfectly symmetric and equal to ± 4 mg. Apparently, under the corresponding tremors of the balance beam, a separation of the additional forces of the course of time acting in opposite directions occurred. Only the action of the force that decreases the weight remains on the top, while the force of the opposite direction, applied during a calm balance beam to the suspension point, turns out to be applied to the fulcrum of the balance beam on the balance support. As a result, the reduction in weight is not compensated on the suspension, and a deflection of the balance pointer occurs. According to formula (10):

$$\frac{\Delta Q}{Q} = \frac{u}{c_2}\,. \tag{25}$$

From this, using the presented data, we obtain that $c_2 = 550$ km/s. Since the direction of the additional forces in the experiment corresponds to Formulation 8 of Chapter III, we conclude that the constant c_2 is indeed positive in a left-handed coordinate system. This result coincides in sign and magnitude with the estimate of c_2 made in Chapter IV, obtained from the asymmetry of the figures of the planets. The planets and the top differ so sharply in size and angular rotation velocities that the equality of the effects caused by them is in itself excellent proof of the proportionality of the forces of the course of time to the linear rotation velocities.

In the described experiments on weighing tops, a decrease in ΔQ was observed with the addition of a non-rotating load to the top. Most likely, there is nothing fundamentally new in this effect, and it is simply associated with a change in the balance vibration regime under additional loading. In any case, it shows that in such experiments, unnecessary weighting of the top should be avoided.

In addition to the experiments with weighing, we investigated the question of the possibility of deflection of a suspended top with a horizontal axis from the suspension line. Just as in the main experiments with the balance, no deflection of the top's suspension line was observed during its rotation in a calm regime. However, in a special regime, when the tremors of the top were transmitted to the suspension point, a shift of the suspension line from the vertical was observed toward the side from which the rotation appeared to occur counterclockwise. This effect at a thread length equal to 2 m and at a rotation velocity $u = 25$ m/s was 0.07 mm. Thus, the ratio of the horizontal force to the total body weight was 3.5×10^{-5}. The ratio of interest to us, ΔQ to the rotor weight Q, is obtained by multiplying the found value by $(a + Q)/Q$, where a is the weight of the frame. For the top in the experiment, $Q = 70$ g and $a = 30$ g; therefore, $\Delta Q/Q = 5.0 \times 10^{-5}$, and by formula (25) we find: $c_2 = 500$ km/s. It is important to note that when the axis of the top was located in the meridian plane, a superposition of an additional northward shift onto the top's own displacement was observed due to the horizontal projection of the Earth's rotation effect during load vibration.

The described experiments establish with certainty the existence of causal mechanics effects associated with the direction of rotation. However, a significant disadvantage of these experiments is the impossibility of simple reproduction of the required vibration regime. Therefore, it is desirable to proceed to such experiments in which an accessible regulation of the vibration source would be available. For this, the vibrator must be independent of the rotor and connected to the non-rotating parts of the system. Therefore, subsequent experiments were set up in exactly the same way as the load vibration experiments described in Chapter IV to clarify the effects of the Earth's rotation: on a pendulum, vibration of the suspension point was carried out, and on a balance, vibration of the support platform of the balance beam. In these experiments, a gyroscope of aviation automatics was used with the following characteristics: $D = 4.2$ cm, $Q = 250$ g, with a frame weight $a = 150$ g. Current was supplied to this gyroscope by the method described at the beginning of this Chapter, and observations were performed at a constant rotation velocity. These experiments immediately clarified a very significant circumstance. Since the vibration source turned out to be connected to the stationary parts of the system, all effects reversed their sign: additional forces began to act on the top along its axis toward the side from which the rotation appears to occur clockwise.

In experiments on the deflection of a suspended gyroscope with a horizontal axis from the plumb line, the gyroscope on a steel wire with a diameter of 0.15 mm and a length of 3.30 m was suspended from a plate of a firmly secured vibrator. It turned out that to obtain a deflection of the average position of such a pendulum from the plumb line, it is necessary to comply with conditions that are in all respects similar to the conditions for obtaining the effects of the Earth's rotation. The deflection of the gyroscope in the direction of its axis was obtained only during parametric resonance, when the projection of the horizontal forces attached to it onto the direction of the gyroscope axis reached a certain critical value of the same order as in the experiments with the effects of the Earth's rotation. The deflection from the plumb line always occurred jump-wise and maintained a certain value, independent of a further increase in the projection of the wire vibration amplitude. In the case when the gyroscope axis was located along the meridian, the combination of the top and Earth effects stood out clearly. For example, at 300 rps and with the position of the top's rotation vector j to the south, a deflection of 0.18 mm was obtained; with the opposite position of the rotation axis, the effect was only 0.05 mm. Table V presents a summary of numerous measurements of the linear displacements of the gyroscope relative to the plumb line, corrected for the Earth's rotation effect.

Table V

Angular velocity, rps	Linear rotation velocity, m/s	Linear deflection from the plumb line, mm
200	26	0.08
300	40	0.12
400	53	0.16

From this Table, it can be seen that the effect is indeed proportional to the rotation velocity. The ratio ΔQ to the total weight of the gyroscope, reduced to a velocity $u = 40$ m/s, is 3.6×10^{-5}. To obtain the ratio $\Delta Q/Q$, it is necessary to correct the value presented above for the weight of the frame by multiplying by $(Q + a)/Q$. By special experiments, in which the weight of the frame was intentionally increased, it was shown that such a correction is indeed necessary. As a result, at $u = 40$ m/s, $\Delta Q/Q = 5.7 \times 10^{-5}$, and consequently $c_2 = 700$ km/s.

It is important to note that to obtain the effects with a gyroscope, it is necessary to take some special measures that are insignificant for obtaining the effects of the Earth's rotation. It turned out that the gyroscope effect completely disappears when the vibrator is installed insecurely, i.e., when it can set into oscillation some non-rotating parts of the system. The effect of the Earth's rotation, however, remains in this case.

Experiments with the balance showed that it is possible to select such a vibration regime of the balance beam when a reduction in the weight of the gyroscope occurs during clockwise rotation and its increase in weight occurs during counterclockwise rotation from the viewpoint of an observer looking from above. For our gyroscope, at 300 rps, the effect in one direction was 15 mg. Thus, $\Delta Q/Q = 6.0 \times 10^{-5}$ (at $u = 40$ m/s), from where using formula (25) we find $c_2 = 670$ km/s, in excellent agreement with the result obtained from horizontal displacements. Obviously, the coefficient α in formula (4), which determines the value of c_2, has a value close to $\alpha = 2$. It is necessary to note that the same effects in magnitude and sign can be obtained with a vibrator located not separately from the balance, but on the opposite end of the balance beam as a balancing load. From this it follows that the role of the vibration source in these experiments is played by the fulcrum of the knife-edge of the balance beam. Just as in the experiments with a plumb line, more special conditions are required to obtain the effect with a gyroscope on a balance than to detect the effect of the Earth's rotation. During the weighing of gyroscopes, despite a large number of experiments, it was not even possible to precisely establish the conditions under which the effect must definitely be obtained.

From the experiments with the vibrations of loads on the Earth's surface and with the vibrations of gyroscopes, interesting conclusions can be drawn that bring us closer to a better understanding of the meaning of causal relationships and the course of time. In experiments of both types, the cause-and-effect relationship is studied at two points: the support and the center of gravity of the body. In the absence of vibrations, the gyroscope axis, where its center of gravity lies, and the support are in a conventional cause-and-effect relationship, which is determined by the pseudovector $+ic_2$ for the action of the cause. On the Earth, the same thing occurs: although an additional force acts on the load, arising due to relative rotations inside the Earth, it will act on the support, like any other force, with a course of time $+ic_2$. From our experiments, it can be seen that due to vibrations, an additional course of time of rotations appears in the support-body system. This can be understood in the following way: the projection of horizontal forces onto the direction of the axis of rotations, like any force, reveals the course of time along the direction of its action. Therefore, arising during vibrations directed along the axis of rotation, the cause-and-effect relationship will act with an additional course of time of rotations. Once arisen, such a course of time will already determine all the cause-and-effect relationships of the support-body system. Therefore, the body's weight will also act with the additional course of time, which will lead, according to formulas (8)–(10), to additional forces proportional to the weight. In the experiments, we dealt with forced vibrations that were maintained by a source located either in the body itself (the top's own vibrations) or at the support point connected to the vibrator.

Let us examine the first case, when the cause of vibrations is associated with the body itself. In experiments with a gyroscope, the projection of horizontal forces establishes for the cause-and-effect the course of time $(ic_2 + ju)$, since the cause of vibration is located in the rotation ju relative to the effect. After this course of time is established, the weight of the gyroscope according to formula (10) will change by the value $-j(u/c_2)|Q|$ or $+j(u/c_2)|Q|$, if all coefficients are considered positive. This change in weight will be accompanied by a reaction at another point of the support-body system, i.e., on the support of the balance beam or at the suspension point of the pendulum. In experiments with load vibrations to detect the effects of the Earth's rotation, the course of time for the action of the cause will become equal to $ic_2 + j\gamma(p)$, which will change the weight of the load A by the value $j\gamma(p)|A|$.

In the second case, when the cause of vibrations is associated with the support point in the experiment with a gyroscope, the vibrations will establish the course of time $(ic_2 - ju)$ between the support and the gyroscope. Indeed, in this case, the cause rotates relative to the effect with a velocity $-ju$. This course of time will lead to a change in every cause, and consequently, to a change in weight by the value $-j(u/c_2)|Q|$, if all coefficients in this expression are considered positive. An additional force results, acting on the gyroscope toward the side from which the rotation appears to occur clockwise. The effect becomes opposite to the effect of the first case, just as was actually observed. For the effects of the Earth's rotation, there will be no change of sign. The course of time for the action of the cause will remain, as before, $ic_2 + j\gamma(p)$, because for the Earth, regardless of the position of the vibration sources, the causes are always associated with the inertia of the load or its weight, and the effects with elastic forces.

From the circumstance that the gyroscope effect changes sign when the vibration source is transferred, while the Earth effect does not change, follows the greater stability of the Earth effect. Therefore, for its reproduction, such pure conditions are not required as in experiments with a gyroscope. On the other hand, in experiments with a gyroscope, one can infer the position of the vibration source from observations of the deflection of the balance and the pendulum. This possibility of searching for a cause is a characteristic and highly important feature of causal mechanics.

Additional forces excited by vibration will act like most ordinary forces. Therefore, the system can have the conventional course of time ic_2 with these forces as well. It appears possible that a further increase in vibrations will bring the system with additional forces back to the course of time of rotations again. As a result, another such additional force will appear, and so on. Therefore, in experiments with vibrations, one can expect the appearance of forces:

$$\begin{aligned} &\text{for a gyroscope} \qquad \Delta Q = \pm\, jn\,\frac{u}{c_2}\,|Q|\,, \\ &\text{for the Earth} \qquad \Delta A = +\, jn\gamma(p)\,|A|\,, \end{aligned} \tag{26}$$

where n is any positive integer. As was mentioned in the previous Chapter, sometimes in experiments with vibrations, it was apparently possible to observe a state corresponding to $n = 2$.

The performed experiments clarify a highly important circumstance, which consists in the fact that the additional course of time of rotating bodies is not simply a relative rotation. The additional course of time appears due to relative rotations, but once arisen, it manifests itself independently of the state of relative rotations in other causal connections. Indeed, in experiments with the effects of the Earth's rotation, relative rotation between the body and the support simply does not exist. In experiments with a gyroscope during vibration of the support, the rotation of the gyroscope, from the viewpoint of the "weight-elastic forces" causal connection, occurs in the direction opposite to the course of time established due to vibrations. To reveal the course of time, negligible circumstances (small forces in the direction of the axis of rotations) are sufficient, after which the modified course of time can create noticeable additional forces to the large forces already existing in the system. These circumstances and the discreteness of states described by formula (26) are completely unusual for classical mechanics, but they are characteristic of atomic mechanics. The appearance of this type of correction to classical mechanics could have been foreseen, for causal mechanics must include, as two limiting cases, classical mechanics and atomic mechanics.

The explanation of the experiments with body vibrations presented above is only approximate and requires much further development in detail. It can be hoped that further experiments in this direction will help find a true, exhaustive understanding of phenomena in causal connections. As can be seen from the entire presentation, this question is very deep, and the present work is only the very beginning of research in this vast field of knowledge.

Concluding the description of the performed experiments, the author considers it his pleasant duty to express his deep gratitude to V. G. Labeysh for his great and initiative participation in the execution of most of the experiments in this work, and to L. A. Sukharev for many valuable pieces of advice, which we constantly used during these investigations.

Conclusion

Mechanics is the foundation upon which the entire edifice of exact sciences is built. At the same time, theoretical mechanics has been developed for only two extreme abstract cases: 1) Newton-Einstein mechanics, corresponding to a World with an infinite course of time ($c_2 = \infty$) and 2) atomic mechanics, which is a certain representation of the mechanics of a World with a zero course of time ($c_2 = 0$). In the real World, however, as the experimental and theoretical material presented in this work shows, the course of time c_2 is a finite quantity. Therefore, exact sciences developed deductively without taking into account the finiteness of the course of time cannot give a true representation of the World. Natural sciences, developed mainly inductively and without rigorous precision of conclusions, give instead a more complete representation of the possibilities existing in the World. This gap between natural science and exact sciences must disappear as soon as exact sciences begin to rely on mechanics that takes into account the finiteness of the course of time and other possible properties of causality.

Newton-Einstein mechanics and atomic mechanics lead to the First and Second laws of thermodynamics. Therefore, in Worlds corresponding to these mechanics, only processes are possible in which an increase in entropy occurs, leading to thermal death. The real World, thanks to the finiteness of the course of time c_2, possesses its own peculiar properties. This World can combat death with opposing processes, which can be called the processes of life, if this word is used in its broadest sense.

We do not yet possess sufficient data to carry out a rigorous analysis of the possibility of such processes in a World with a finite c_2. However, the fundamental possibility of resisting the increase in entropy follows already from a number of conclusions obtained in the present work. Indeed, the rotation of interacting bodies at a finite c_2 leads to the emergence of additional forces, and consequently, additional energy. In a system close to equilibrium, accidental changes in relative rotations in its various parts can lead to an increase in total energy. Therefore, the damping of a system — i.e., the disappearance of the kinetic energies of its individual parts — may turn out to be impossible. As a result, a system located near equilibrium will become a machine producing energy. Stars are likely exactly such systems.

The possibility of using the course of time — i.e., the non-equivalence of the past and the future — to obtain work is an interesting but not the most important consequence of causal mechanics. Using the example of experiments with gyroscope vibrations, we saw that very small effects of vibrations can establish additional cause-and-effect relationships in a system of rotating bodies, causing noticeable mechanical effects. This possibility to interfere in existing cause-and-effect relationships means that one can master the flow of time in order to enhance processes acting against the increase in entropy, i.e., the processes of life. The phenomena observed in the described experiments give only a certain hint that what has been said is not an empty dream, but has a foundation in reality. Concrete mastery of time will, of course, become possible only after a thorough study of its properties. The present work shows that such a study of time is entirely possible by means of ordinary physical experiments.

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Afterword: The Evolution of Causal Mechanics

The English translation of N. A. Kozyrev's fundamental monograph, *Causal or Asymmetric Mechanics in a Linear Approximation* (1958), just published in the journal *Progress in Physics* pursues two crucial and urgent tasks in modern physics. First, this publication restores historical and scientific justice. True, modern physics journals have a growing number of publications on the physical properties of time, nonlocal causal interactions, and the anomalous mechanics of rotating macrosystems. However, N. A. Kozyrev's original work, which pioneered this research field, is not mentioned. By presenting this fundamental monograph, written by Kozyrev in 1958, we restore direct access to the origins of causal mechanics to the international scientific community. Second, this comprehensive study proves that Kozyrev's concept of the physical properties of time is not a "fossilized relic". It represents a living paradigm that has evolved from early phenomenological observations to a highly developed mathematical apparatus, and has also found various fundamental applications in geophysics, forecast meteorology, and astrophysics.

In his Afterword to Kozyrev's *Selected Works* [1], published in 1991, L. S. Shikhobalov provided a rigorous scientific and critical assessment of causal mechanics based on modern theoretical physics. He showed the mathematical correctness of causal mechanics: as the "flow of time" approaches infinity, causal mechanics is converted into Newtonian classical physics. His analysis legitimises Kozyrev's concept of time, in which time represents an active physical substance capable of transmitting energy, reducing the entropy of a system, and serving as a source of stellar energy, thereby affirming Kozyrev's theory as a fundamental expansion of the modern physical worldview.

To transform this theory into a reliable tool for practical forecasting, long-term experimental monitoring setups were deployed, in particular — the measurement stations using the deep-sea vertical measuring system of the Baikal Deep-Sea Neutrino Observatory [2, 3]. Since water masses are colossal dissipative systems, and the globules of Lake Baikal are ideally isolated from electromagnetic interference on the Earth's surface, these sensors turned out to be uniquely suited to recording purely transactional fields of time density. Long-term experiments provided empirical evidence to the fact that large-scale, highly chaotic dissipative processes (such as major solar activity events, geomagnetic storms, and macroscopic tectonic friction) are quantum entangled in time. Most importantly, complex nonlocal correlations (retrocausality) were recorded. Specifically, sensors in depth of Lake Baikal recorded distinct electrical anomalies days or weeks before the actual physical manifestations of major solar flares or seismic tremors were detected on Earth. Now, this application has expanded beyond a purely experimental approach. It serves as a functional mathematical basis for long-term, proactive forecasting of hazardous heliogeophysical and geodynamic phenomena.

The experimental investigations performed by N. A. Kozyrev proved to be even more significant. Thus, he discovered a connection among various dissipative (irreversible) processes occurring "through the physical properties of time" — that is, without the involvement of local interaction carriers [4]. Furthermore, these processes revealed a surprising reversibility of information [4–7]. Years later, these ideas were further developed in the works of other researchers.

Although Kozyrev's early experiments were often dismissed by critics as vulnerable to local noise or thermal interference, this paradigm has received irrefutable confirmation in highly respected academic circles. In the late 1980s and early 1990s, a research group conducted by M. M. Lavrentyev, a Fellow of the USSR Academy of Sciences (Institute of Mathematics, Siberian Branch of the Academy), undertook a verification of Kozyrev's unique astronomical observations [5–7]. In fact, they tested Kozyrev's original astronomical observations [5–7], in which he showed that stars influence a detector sensitive to local fluctuations in time density. Lavrentyev's team published their results in the prestigious journal *Doklady Acad. Sci. USSR* [8, 9]. In brief, using modern, high-precision equipment and a 1.25-meter reflecting telescope, they confirmed that any star simultaneously influences a detector (sensitive to changes in time density) from the following three of its space-time states:

1. Past (optical/visible) position. This is the star's position in the sky, as seen by the eye. It originates from electromagnetic radiation, which travelled at the speed of light and was emitted by the star many years (or centuries) ago.

2. The present (true/physical position) is the star's actual position in space at the moment in time when the observation was made. Since the star traveled along its trajectory in space during the time it took its light to reach the Earth, its physical position in the sky is shifted relative to its visible/optical image. In the observations of Kozyrev and then Lavrentyev's group, a detector sensitive to time density fluctuations registered a signal from this position for each of the observed stars. This proves that the Kozyrev "time density waves" do not propagate along electromagnetic signal trajectories, but act as an instantaneous (non-local) informational basis that instantly connects cosmic objects at any distance.

3. The future position, symmetrical to the past/visible position relative to the star's true (middle) position in the sky. Most notably, the detector recorded this third signal. This position of the star in the sky indicates its future location exactly at the same time it takes light to travel from it to the Earth.

The experimental data obtained by Lavrentiev's group verified the conclusions of Kozyrev's causal mechanics, according to which the flow of time is a physical reality. Namely, — past, present, and future are not abstract psychological concepts; they are physically woven into a single cause-and-effect fabric, where future states are structurally manifested in the active property of the universal flow of time.

Recently, D. Rabounski and L. Borisova [10] had successfully explained Kozyrev's astronomical observations of instant transmission of signals from the past, present and future positions of of stars in the space-time of the general theory of relativity, using the mathematical apparatus of physically observable quantities (known as the Zelmanov chronometric invariants).

The rise of causal mechanics from the state of an astrophysical hypothesis to a solid mathematical science having a great practical prospect represents the most important stage in its modern evolution. At this stage, the works of M. L. Arushanov, who discovered the consequences of causal mechanics in the global atmospheric and climatic systems of the planet [11, 12], played a key role.

For decades, classical hydrodynamic models for weather and global climate forecasting have faced an invisible wall of chaos and unpredictable turbulence. Arushanov's study [12] established that this limitation stems from a fatal flaw in standard atmospheric physics: considering time as an inert, passive background parameter. In contrast, in [12], the asymmetric properties of time were directly integrated into the fundamental equations of atmospheric hydrodynamics. By considering the Earth's rotational asymmetry not simply as a source of Coriolis' forces, but as a macroscopic generator of local variations in time density, this work led to the formulation of new barotropic and baroclinic atmospheric models. The practical application of causal models has improved the accuracy of long-term weather forecasts and climate trends. Equations derived in the framework of these models successfully resolved the "energy dissipation paradox" in atmospheric circulation, demonstrating that the asymmetric flow of time physically pumps energy back into large-scale cyclonic and anticyclonic structures. Furthermore, by applying these principles to planetary geophysics in [11], Arushanov demonstrated that the actual physical shape of the Earth's geoid (including its local gravity anomalies and tectonic fault lines) is a direct physical "print" of the interaction between the asymmetrically rotating planetary mass and the universal rate of time c_2.

In my subsequent research [13], a fundamental synthesis was achieved connecting causal mechanics with modern quantum information theory and the Wheeler-Feynman absorber theory. It demonstrates that the Kozyrev "active properties of time" are a macroscopic manifestation of quantum nonlocality operating on planets and stars. In my subsequent work, conducted jointly with co-authors [2], it was established that, due to the universality of this phenomenon, experiments on detectors of macroscopic nonlocal correlations yield results that are close to one another.

The urgent need for this translation is underscored by a profound historical paradox that unfolded in world physics journals at the end of the 20th century. In 1989, Japanese physicists H. Hayasaka and S. Takeuchi published sensational results of their experiment in *Physical Review Letters* [14]. Their experiment, which was a reproduction of some of Kozyrev's experiments, showed that a right-rotating gyroscope in the Earth's field experiences an anomalous, unidirectional decrease in weight. This result contradicts classical Newtonian mechanics and general relativity. Remarkably, Hayasaka and Takeuchi [14] fulfilled the necessary condition for the effect to manifest itself (originally discovered by Kozyrev), namely, — the vibration of the gyroscope, — but they did not emphasize this important circumstance in their paper. As a result, others who attempted to reproduce their experiment strove for the "highest quality factor", resulting in the gyroscope in their experiments being vibration-free, and they ultimately obtained a zero result.

For those familiar with the history of science, this was a direct reproduction of the key postulates of causal mechanics and laboratory setups first developed by Kozyrev and described in his 1958 book, as well as subsequent publications. Kozyrev had spent decades studying how the asymmetric flow of time acts as an active, force-generating substance that interacts with rotating masses and changes their weight depending on the speed and direction of rotation. Remarkably, Hayasaka and Takeuchi did not include even a single reference to Kozyrev's original work in their paper.

This glaring omission was not an exception, but showed a general trend. International research teams repeatedly documented macroscopic mechanical anomalies, local gravitational fluctuations, and rotational asymmetries, treating them as their own "new discoveries". Because Kozyrev's original works remained untranslated into English, the international scientific community remained unaware that a comprehensive theoretical framework capable of explaining these phenomena had been developed by him back in 1958. This publication of *Causal or Asymmetric Mechanics in a Linear Approximation* in English forever breaks this barrier, forcing the international scientific community to acknowledge Kozyrev's priority in the field of asymmetric rotational mechanics.

In addition to the above, many modern foreign physicists are actively integrating Kozyrev's axioms into the vanguard of contemporary science.

Thorsten Ludwig (Germany) conducted a thorough automated laboratory revalidation of the Kozyrev balance and mechanical asymmetric systems [15]. He successfully developed the isolation protocols necessary to separate true time-density effects from trivial thermal artifacts and air currents, providing a basic experimental standard for modern physics.

Takaaki Musha (Japan) extended causal mechanics into the realm of advanced electrodynamics, by considering time not as a static line, but as an oscillating energy wave capable of performing macroscopic physical work [16]. Musha's mathematical models postulate that manipulating local time density gradients could pave the way for entirely new zero-point energy extraction systems and fuel-free field engines.

Experiments with Kozyrev detectors demonstrate a profound similarity with the principles of modern delayed-choice quantum erasers, first proposed by M. Scully and K. Drühl [17]. The connection demonstrated in their work conceptually correlates instantaneous nonlocal information transfer in causal mechanics with macroscopic quantum entanglement.

This English translation of N. A. Kozyrev's fundamental monograph does more than simply look back to the past to preserve his scientific legacy. This publication serves as an indispensable guide for the future of physics. By demonstrating how Kozyrev's early linear approximations evolved into relativistic tensor models, testable cosmological data, high-precision meteorological systems, and predictive quantum-geophysical signaling networks, this publication also calls on the international scientific community to maintain an ethical attitude to Kozyrev's works. This publication forces us to stand "face to face" with a Universe where time is no longer an empty, passive coordinate, but an active, energy-carrying and causal architect of reality.

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